

THE EFFECTS OF STEREOSCOPIC 3D TECHNOLOGY: LIMITED CAPACITY, AND
A PROCESS-ORIENTED MODEL OF SPATIAL PRESENCE

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ABSTRACT

Research suggests that high-resolution, stereoscopic 3D graphics lead to the experiencing of spatial presence; however, it also has been suggested that low amounts of available cognitive resources negatively affect the experiencing of spatial presence. In this dissertation, the effects of pacing in a shooter game and stereoscopic 3D exposure were investigated using an integrated framework that consisted of the spatial presence model and limited capacity model for motivated mediated media processing (LC4MP). A mixed 2 (stereo 3D vs. 2D [within]) x 2 (high-pacing vs. low-pacing [within]) x 2 (high-skill vs. low-skill [between]) study was used and 57 participants were recruited. Game-related skill was not a significant factor to determine whether participants experienced spatial presence. When those who were more skilled played in stereoscopic 3D, more robust spatial situation models were formed and greater sense of self-location and perceived possible actions were experienced; however, when less-skilled participants played in stereoscopic 3D they did not form more robust spatial situation models and were less likely to experience greater sense of self-location and perceived possible actions. Those who were less skilled did experience greater sense of self-location, but only in the high-paced, stereoscopic 3D condition, which suggested that although they might have not formed strong spatial situation models they were still capable of experiencing spatial presence. The findings of this study suggest that greater game-related skill may lead to a better understanding of the spatial

area and greater propensity to experience spatial presence, and although a stronger spatial situation model might not be constructed when a less-skilled user plays in stereoscopic 3D, its verisimilitude may lead to experiencing spatial presence.

DEDICATION

I dedicate this dissertation to my late grandfather, Arthur D. Shores, who served as the local counsel on *Lucy v. Adams*, the landmark case that resulted in the racial integration of The University of Alabama.

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CHAPTER I

Introduction

The term *presence* is described as the sensation of being within a mediated environment. Researchers from various disciplines including computer science, human computer interaction, psychology, communication, and numerous clinical fields have studied the concept of presence and most agree that “the sensation of being within a mediated environment” is an apt description. The construct of presence has been examined to determine its effects on specific outcomes from using mediated content. Studies have investigated its effects, but made no causal links to negative outcomes such as aggression (Ivory & Kalyanaraman, 2007). Other studies have revealed positive effects such as the generation of enjoyment and other positive results within psychotherapies for post-traumatic stress syndrome, phobias, addiction, and autism, and for physical therapy and physical rehabilitation (Coelho, Waters, Hine, & Wallis, 2009; Haniff, Chamberlain, Moody, & De Freitas, 2009; Riva & Mantovani, 2012; Tamborini & Skalski, 2006; Weiss, Kizony, Feintuch, & Katz, 2006).

The construct of presence is studied to gain an understanding of (a) an individual’s experience when exposed to mediated content, for example, a virtual environment, and (b) the effects of that exposure on a variety of outcomes. Recently, investigators have examined the relationship of this construct to clinical outcomes vis-à-vis its capabilities for developing positive benefits within users’ lives. If clinical research regarding the concept of presence is so salient, research that examines the experience of presence achieved when playing video games will certainly add value to this line of inquiry.

The study of presence, as it occurs during video game playing, is useful for a few reasons. First, video game media have the greatest capacity to induce presence and, therefore, should be central to understanding its phenomena (Tamborini & Skalski, 2006). Since video games elicit strong effects, those games should be the most fruitful medium from which a better understanding of presence and its processes can be gained (Tamborini & Skalski). Second, a greater level of presence has been associated with higher levels entertainment (e.g., Ellis, Janicke, & Raney, 2011), which—from an entertainment theory perspective—is useful and may benefit clinical outcomes as well.

Spatial presence is posited to be a component of presence. It can be described as the psychological location within a virtual environment (Wirth et al., 2007). In three-dimensional games, the environment is rendered in real time in which navigation and exploration can occur (Fernandez-Vara, Zagal, & Mateas, 2007). This type of game allows movement on three axes, up and down; left and right; forward and back, enabling users to navigate in a virtual environment much the same way as they would in real life.

This dissertation examines stereoscopic 3D, video game pacing, and player skill to investigate how users' experiencing of spatial presence are affected by their limited capability to process information. Two theoretical models are used to organize this study's conceptual framework. The *spatial presence model* posits that spatial presence is a two-step process, the first of which is the construction of a mental representation of the virtual environment and the second of which is the experience of spatial presence as the sensation of self-location with a concomitant increased capability to act within the environment (Wirth et al., 2007). The *limited capacity model for motivated mediated messages processing* (LC4MP) (Lang, 2005) is the second

theoretical model used to structure the study's framework. LC4MP explains the effects of the availability of cognitive resources on the processes within the spatial presence model.

Video games are a very popular entertainment form used by individuals throughout the world. Data collected during 2013, within the United States, suggest that the average household owns one video game console, personal computer (PC), or smartphone dedicated to playing video games, and 59% of Americans reported playing some type of video game (Entertainment Software Association [ESA], 2014). During the past several years, the sales of video games have increased to rival the levels of other dominant forms of media such as music and motion pictures. Video games software sales in the United States during the years 2011, 2012, and 2013 equaled \$16.54, \$14.80, and \$15.39 billion, respectively (ESA, 2012; 2013; 2014). When hardware and accessories sales are added to these sales figures, the revenue of the video game industry is actually 25% larger; for example, in 2013 the total sales for video game hardware and software amounted to \$21.53 billion (ESA, 2014).

The video game industry continues to flourish. Meanwhile, as the imaging qualities of flat panel displays continue to be refined, the price of these displays continues to decline. Newer flat panel displays offer a variety of smart television features and increased graphical fidelity. Many televisions now feature *stereoscopic 3D* (stereo 3D) capabilities, and many major suppliers have begun producing *ultra-high definition televisions* (UHTVs), such as the 4K televisions that feature twice the resolution of conventional *high definition televisions* (HDTVs). In addition to these advances, smart phone technologies include miniaturized HD displays and accelerometers that have lowered the costs manufacturing *head mounted displays* (HMDs). An HMD is unique because it serves as an interface device that enables an immersive stereo 3D view of virtual environments.

Stereo 3D is a feature available on a wide variety of displays, including computer monitors, HMDs, HDTVs, and UHD TVs. Many critics of stereo 3D have suggested that the technology has failed to gain traction with consumers. Only 6% of U.S. households owned stereo 3D capable televisions in 2012. That percentage is increasing: in 2013 more than 18% of the new television sales included stereo 3D capabilities (Kline, 2014). Forecasts suggest that as many as 58% of all televisions sold worldwide by 2017 will feature stereo 3D capability. As sales of digital displays continue to grow, a greater number of consumers will continue to gain access to stereo 3D display capabilities in this country and abroad (Kline).

If the current generation of video games can be played on a regular HDTV display, which offers adequate monoscopic cues to help the user navigate the virtual environment, then how would stereo 3D technology be beneficial to game players? The enhanced visual experience offered through stereo 3D graphics is alleged to increase users' game-playing enjoyment (Ellis et al., 2011; Litwiller & LaViola, 2011). Another benefit of an enhanced visual experience is the feeling of increased presence and spatial presence within the virtual environment that comprises a video game (Ellis et al., 2011; Rajae-Joordens, 2008; Takatalo, Kawai, Kaistinen, Nyman, & Häkkinen, 2011). Spatial presence has been described as the feeling of being psychologically located or present within a virtual environment offered by a video game (Lee, Kim, Rizzo, & Park, 2004; Shim & Kim, 2003).

Stereo 3D gaming is more accessible and available than it may seem to be. *Microsoft Direct X 11.1* and many major video game engines (e.g., *Cryengine*, *Unreal*) support stereo 3D graphics with little effort required of the developer, and many games that support stereo 3D are being developed or were released for use with personal computers and game consoles. Many game users can install stereo 3D rendering software, such as *Nvidia 3D vision* or *TriDef* to play

older computer games that do not feature native stereo 3D support. Wirth et al. (2007) suggests that 3D stereoscopy coupled with a user's egocentric experience of the environment increases his or her propensity to experience spatial presence. Since that egocentric view can facilitate the processes within the spatial presence model, the propensity of an individual to experience spatial presence is increased when the game is played in first person. For example, the *first-person shooter* (FPS) game is one of the most popular forms within a video game genre. When games are played from an egocentric, first-person point of view they offer a perspective that is similar to that which the user experiences in everyday life. This perspective is in contrast to a third-person point of view in which the game avatar and its location within the environment is displayed and visible to the user. The first-person perspective allows the user to manipulate his or her view, perform actions, and manipulate the environment as he or she navigates through the virtual world. There are many first-person perspective games, including the *Call of Duty* franchise, the developer of the highest grossing shooter games in the United States and most of the western world. According to the ESA (2010, 2011, 2012, 2013), the highest grossing console video games in the United States from 2009 to 2012 belonged to the *Call of Duty* franchise: *Call of Duty: Modern Warfare 2* (2009); *Call of Duty: Black Ops* (2010); *Call of Duty: Modern Warfare 3* (2011); and *Call of Duty: Black Ops 2* (2012).

Users can enjoy spending time playing first-person shooter games by themselves through a single-player campaign mode or with other people in various multiplayer modes. Users playing first-shooter games who have honed their shooting skills after many hours of game use also develop cognitive efficiencies and possess greater visual-spatial attention. Green and Bavelier (2003, 2006a, 2006b, 2006c, 2007) suggest that those who play action games develop specialized skillsets that help them participate in fast-paced games. Some of those skills promote a user's

capability to track more objects projected simultaneously onto the screen and to attend quickly to subsequent stimuli introduced into the environment. Although playing games in stereo 3D should facilitate the users' experiencing of spatial presence, the game's pace can affect the user's processing of the media. When a user's cognitive ability is taxed, the cues provided by stereo 3D imagery and graphics may not be so helpful to the user while he or she attempts to interpret the virtual environment, which decreases the likelihood that the user will experience spatial presence (Lee & Kim, 2008). In fact, Lang (2005) suggests that inexperienced game users can become cognitively overwhelmed in certain situations and "shut down" during game use. Although, a fast-paced game can adversely affect the experience of spatial presence for some users, adept game players may not be adversely affected.

Pacing has been described and operationalized in various ways that can be expressed differently by genre. Pacing can be dictated by the game's narrative or by the building of tension within the game or by the number of problems provided to a user to be resolved (Davies, 2009; Myers, 1992). However, one aspect of increasing the pacing of a video game can be described as the increase in the number of virtual enemies a user must confront within a situation (Myers). Within the context of a first-person shooter video game, the greater the number of virtual agents within a spatial scenario, the quicker the pace of the game. The player must overcome more challenges within the specific space of the game.

Some game users may think of themselves as less efficacious while playing a particular video game because they have difficulty understanding and navigating the virtual surroundings. Although stereo 3D provides helpful cues, those users with fewer or less honed skills may not be able to accomplish the required tasks, thus decreasing their enjoyment of the game and discouraging them from playing certain game genres or even dissuading them from playing

video games as an entertainment medium. Conversely, if the incorporation of stereo 3D and pacing could produce positive effects for less skilled game users, then developers could design games accordingly to orient better those users to the virtual environment, thus leading to their greater enjoyment. Lee and Kim (2008) suggest that available cognitive resources are required to experience spatial presence. The initial processes associated with spatial presence, that is, the construction of the mental representation of the environment, can vary among users when stereo 3D and different pacing levels are present. Similarly, skilled and unskilled users may experience Wirth et al.'s (2007) two-dimensional structure of spatial presence, which includes sense of self-location and perceived possible actions, very differently. However, it is not fully understood how stereo 3D affects the processes of the model of spatial presence or how stereo 3D vis-à-vis pacing levels affects users with different levels of skill.

The questions this study seeks to answer include:

1. Does stereo 3D present unskilled users with sufficient cues to process the media if the level of pacing is slow?
2. How do processes of the spatial presence model differ when skilled and unskilled users play a first-person shooter game?
3. Does stereo 3D facilitate the initial spatial representation of both skilled and unskilled users?
4. How can altering the level of pacing affect users' sensation of self-location and perceived possible actions?

The purpose of this study is to investigate the manner in which stereo 3D and video game pacing affect the processes of spatial presence with users of differing skill levels. The primary objectives of this study are fourfold:

1. Examine the effects stereo 3D and pacing have on users' mental representations of the game environment.
2. Determine whether greater playing skill induces a stronger mental representation of the virtual environment and facilitates the experience of sense of self-location and perceived possible actions.
3. Investigate the ways by which the processes and dimensions within the spatial presence model are affected by the presence of stereo 3D and user playing skills.
4. Examine whether any two-way interactions exist between stereo 3D and pacing levels on users' spatial mental representation of the environment, their sensation of self-location, and their perceptions of possible actions.

The tenets of two theoretical models were used to achieve this study's objectives. The first theoretical model, the spatial presence model, posits that sensory cues within the media facilitate the construction of a robust mental representation and can be used to form persuasive, perceptual alternatives to reality (Wirth et al., 2007). Spatial presence is experienced when the user's attention is bound to the media because the media presents a suitable perceptual alternative to the psychological location of one's reality. Although stereo 3D can facilitate the user's construction of a mental representation of the environment, various factors such as visual-spatial ability and skills exercised while playing a specific video game affect the availability of cognitive resources and the experiencing of spatial presence. When fewer cognitive resources are available, the media is not fully processed, and as Lee and Kim (2008) suggest insufficient cognitive resources can impede the experiencing of spatial presence.

LC4MP is the second model used as a theoretical basis for this study. Its framework explains how some factors—game pacing, users' playing skills, and motivational relevance of

the game—affect attention and the availability of cognitive resources. An integration of each model’s framework is used to (a) facilitate an understanding of the effects of visual cues on spatial presence, (b) test the theoretical propositions of the spatial presence model, and (c) understand how other factors affect the availability of cognitive resources and the experiencing of spatial presence.

Previously conducted research suggests that playing a game with stereo 3D increases a user’s sensation of presence; however, no research has examined how a user’s playing skills in relation to the pace at which the game is presented to that user could potentially affect the two levels of the spatial presence model. Using Wirth et al.’s (2007) model, Wu (2010) found a positive correlation between self-reported user skill and the strength of the mental representation of the environment during video game use; yet, no previous literature has examined the effects of stereo 3D and user skill within the process-oriented model of spatial presence. Few studies have investigated the relationship between cognitive efficiency and spatial presence; namely, users with greater game-playing skills require less cognitive resources thereby contributing to the availability of more allocable resources and a greater likelihood of experiencing presence. The present study expands the previous research by examining the effects of stereo 3D and pacing on three dependent variables: the formation of the user’s mental representation of the environment, which is the first step to experiencing spatial presence, and the two dimensions of spatial presence, sense of *self-location* and perceived *possible actions* within the game.

In Chapter II, the literature that is salient to the topic of this dissertation is discussed, including the concepts of presence, spatial presence, and explications of the spatial presence model; stereo 3D technology; pacing of video games; game play competence; and LC4MP. Propositions of the two theories are synthesized. Hypotheses are proposed. Chapter III discusses

the methodology used, including the design of the study, special apparatus, measurements, pretesting procedures, indexes, and the statistical tests. Chapter IV presents the results of the study of the hypotheses. Chapter V is a summary of the findings of the study, conclusions that are drawn, limitations, and future directions for research.

CHAPTER II

Review of the Literature

This chapter presents the pertinent literature for an understanding of the concepts discussed throughout this document. It begins with a brief discussion of presence with an explanation of the spatial presence model. Stereo 3D and its effects on the spatial presence model are presented. Pacing as it is employed in video games is defined, users' game-playing skills are discussed and categorized by level of game play competence, and visual, cognitive skills that allow experienced game users to overcome situations of fast pacing and advanced difficulty are highlighted. LC4MP and its implications for both skilled and unskilled video game users are discussed. In conclusion, the second chapter is summarized, and several hypotheses and research questions are proposed.

Presence

The construct of presence is a complex, multidimensional paradigm (e.g., International Society for Presence Research [ISPR], 2000; Wirth et al., 2007) that has been broadly examined by researchers of various fields and disciplines, including philosophers, psychologists, computer scientists, and engineers (Tamborini & Skalski, 2006). Many scholars define presence as a psychological state or subjective perception in which even though part or all of an individual's current experience is generated by and/or filtered through human-made technology, part or all of the individual's perception fails to accurately acknowledge the role of the technology in the experience. (ISPR, 2000)

In their seminal review, Lombard and Ditton (1997) discussed six prominent conceptualizations of presence, many of which became precepts of the ISRP's explanatory statement of the construct. In the first conceptualization, *social richness*, describes the extent to which the user perceives a technology as warm, personal, or intimate. A second conceptualization of the construct emanates from perceptual realism produced by the technological aspects of the media. This *presence as realism* is described as accurate representations of objects, persons, and events to similar, real-life objects, persons, and events. The third conceptualization of presence is illustrated as a psychological *transportation*; that is, the user is mentally transported to another *place*—an alternate reality—while physically lodged in and aware of a real location. *Presence as immersion* focuses on a user's immersion into a virtual world, the depth of which makes the real world invisible. Immersion creates high levels of user involvement: Users are engaged, engrossed, and absorbed by the media (Lombard & Ditton). *Presence as a social actor* within the medium describes presence as the immediacy between the user and the actors within the media. Presence as a social actor suggests that users experience parasocial interaction: They respond to entities within the medium, based on cues those actors present even when it is not logical to do so. The final conceptualization of the construct expresses presence, as *medium as the social actor* in which users respond to the media technology itself as if it were a social entity.

It is evident from Lombard and Ditton's (1997) review of literature that the concept of presence is rich, complex, and diverse. Although some dimensions of presence may differ, many of its conceptualizations rely heavily on a spatial element. In Sacau, Laarni and Hartmann's (2008) conceptualization, for example, they distinguish between two primary dimensions of presence, *social presence*, or the sense of being with or near another entity, and *spatial presence*,

the individual's psychological location within a spatial environment. Similarly, Tamborini and Skalski's (2006) conceptualization of presence supports the dimensions of spatial presence and social presence and adds a third, *self-presence*, which is defined as experiencing the virtual world as if it were the actual self. Although presence is described in various ways, literature suggests that the dimension of spatial presence—the sensation of personal location within a mediated environment—is core to the construct of presence. Since perceived possible actions could be bound to a user's sensation of self-presence, Sacau et al.'s two-dimensional structure more closely reflects the conceptual framework used in this study. Although its conceptualization varies, presence and its dimension of spatial presence are important areas of interest that assist researchers with understanding video game users' experiences. Advancements in graphics technology, which stimulate feelings of being present within a video game, highlight the importance of examining spatial presence (Tamborini, 2000).

Spatial presence. In Lee et al.'s (2004) investigation of stereo 3D effects on spatial presence, the concept was defined as a "psychological state in which virtual objects are experienced as actual objects in either sensory or nonsensory ways" (p. 37). Schubert (2009), who views spatial presence differently, suggests that it could be conceptualized as a cognitive feeling. Under Schubert's purview, an individual's spatial perceptions while engaged with a medium are derived from unconscious processes that create an alignment between the person's physical self and the depicted spatial environment. The description and explanation posited by Wirth et al. (2007) states that experiencing spatial presence is a two-part process. During the first part, salient spatial cues are used to form an initial mental representation of the spatial environment. During the second part, spatial presence is experienced as sense of *self-location* and *perceived possible actions*.

Wirth et al.'s (2007) spatial presence model was selected as the conceptual framework for this study for several reasons. First, in some instances spatial presence has been examined, but not explicated as a multidimensional, multilevel process. Wirth et al.'s model has more than one level, so it may better explain the effects of visual cues on different processes within the model. For example, in Wirth et al.'s model, stereo 3D is capable of affecting users' initial as well as second level of spatial representation of a virtual environment. Another reason to use the model was the availability of a questionnaire designed to measure the constructs within the model: the *Measure, Effects, and Conditions Spatial Presence Questionnaire* (MEC-SPQ) (Vorderer et al., 2004). Several studies have examined the same factors addressed by this dissertation using MEC-SPQ measures. The findings of those earlier studies permit meaningful comparisons and conclusions to be drawn between the findings of this study and other pertinent investigations. Finally, the spatial presence model offers a construct through which a thorough investigation can be made of the manner by which different processes are affected by stereo 3D graphics and allocable resources determined by users' game-playing skills

Wirth et al. (2007) characterizes spatial presence as a binary experience in which an individual experiences both self-location and perceived possible actions while bound to the existing medium. This characterization expresses spatial presence as a multistep and multidimensional process. During the first step, the user's attention is directed to the media from which a mental representation of the spatial environment is formed. This initial formation contributes to the creation of the egocentric or first-person mental representation of the spatial environment. While an individual is enjoying video game play, the egocentric representation assists with the formulation of a perceptual hypothesis of psychological location. The perceptual hypothesis of psychological location within the virtual reality of the video game is juxtaposed to

the perceptual hypothesis of reality the actual physical location where the game is being played. An individual makes subconscious judgments about his or her psychological versus physical locations when he or she consistently accepts the perceptual hypothesis for being located within a game in lieu of the perceptual hypothesis of reality. During the second step, the two dimensions of spatial presence are experienced by the user as sense of self-location and his or her perception of possible actions taken within the virtual environment.

Spatial Presence Model

A discussion of the spatial presence model begins with the user's direction of attention to and the formation of a mental representation of the spatial environment. The experiencing of spatial presences is explained through the selection of an alternate perceptual hypothesis. The role of stereo 3D graphics within these processes of the spatial presence model are discussed.

As noted by Wirth et al. (2007), spatial presence is "a binary experience during which perceived self-location and, in most cases, perceived action possibilities are connected to a mediated environment instead of reality" (p. 497). Perceived self-location is a state of psychological location construed as a sense of personal space within the context of mediated content (e.g., a video game); in other words, "the sense of being physically located within the spatial environment portrayed by the medium" (p. 497). The second part of the experience consists of possible actions that the user can perform within the virtual environment. Prior to experiencing spatial presence, a user must allocate attention toward the video game's content. Each aspect of the model contributes to the sensation of spatial presence; however, since spatial presence is conceptualized as a binary state, the user either experiences or does not experience spatial presence.

Step 1: Attention and the spatial situation model (SSM). Prior to experiencing spatial presence, a video game user's attention must become bound to the media. Three factors can increase the user's attention: content, form, and personal factors (Wirth et al., 2007). Attention directed toward a game is captured in one or both of two ways. Attention is allocated either automatically as *uncontrolled attention* or voluntarily as *controlled attention*. Uncontrolled attention is activated through an *orienting response* or a "What is it?" response that is directed toward the media (Lang, Simons, & Balaban, 1997). Even though attention is allocated automatically to the media, some active concentration is required for this action. Controlled attention directed toward a video game occurs based on game content and user preference.

Domain specific interest (DSI) is the user's level of interest in the mediated content. DSI affects the amount of attention that a user voluntarily directs toward the media. When a user enjoys playing a particular genre of video games, his or her DSI is high because the attention devoted to the game is voluntary. However, if a user does not enjoy playing a game within a particular genre, then his or her DSI is low because the individual chooses to devote less attention to the media.

During the first level of spatial presence, a *mental model* of the mediated space in a game is formed. This model, identified as the *spatial situation model (SSM)*, is a representation of situations, space, and entities involved (Garnham, 1997; Johnson-Laird, 1983; Roskos-Ewoldsen, Roskos-Ewoldsen, & Carpentier, 2002). An SSM is a mental model or cognitive representation of the mediated environment (Johnson-Laird, 1983; McNamara, 1986; Sanford & Garrad, 1981) and is a necessary component for experiencing spatial presence (Wirth et al., 2007). Within a first-person shooter game, a mental model can represent various elements such as a user's avatar, the avatars of allies and enemies, and the environment depicted within the game.

Spatial cues are the building blocks of the SSM. Increasing the number of spatial cues forms a richer, more accurate SSM (Wirth et al., 2007). When using media such as a video game, the user's SSM is considered "complete"; however, the SSM may differ in terms of robustness, which is its internal logical consistency and representational quality (Schnotz, 1993; Wirth et al. 2007). Whereas an SSM is deemed complete, it does contain "empty slots" that can be filled from memory with previously acquired spatial knowledge (NcNamara, 1986). An SSM continues to be constructed as many salient spatial cues are perceived and organized into spatial structures. Stereoscopy provides users with one the cues that help organize spatial structures (Wirth et al., 2007). The SSM's development continues with the simultaneous retrieval and activation of an appropriate spatial scenario and the assimilation of previously perceived spatial cues. The user constantly examines both consciously and subconsciously the amount of congruence between the SSM and his or her perceptions. If a user is confronted with a large disparity between the two, then the SSM can be restructured, extended, or replaced (Van Dijk, & Kintsch, 1983).

An individual's attributes can affect the experiencing of spatial presence while he or she is playing a game. One of these attributes or factors is the individual's *visual spatial imagery* (VSI) ability. VSI is the ability to transfer spatial aspects of media into a mental representation. It facilitates the formation of the SSM with salient visual information that bolsters the SSM (Wirth et al., 2007). Previously gathered spatial knowledge is another factor that can increase the strength of a user's SSM. For example, while playing a game, the user acquires spatial knowledge about the virtual environment of that game. During subsequent play, the user can access the spatial information he or she has stored about that game and automatically place it into the empty slots of the SSM.

Step 2: Experiencing spatial presence. Since the SSM is a direct representation of the environment in which a user will become personally located, the formation of a strong SSM is an important step that directly contributes to the experiencing of spatial presence (Wirth et al., 2007). Once a user forms an SSM of the video game, it is used to generate an *egocentric reference frame* (ERF). An ERF is a first-person mental model that embodies aspects of an individual's surroundings. These surroundings include structures and objects that are constantly updated (Mou & McNamara, 2002; Wirth et al., 2007). Because we, as beings, exist within the real world, each individual's *primary egocentric reference frame* (PERF) is the physical environment that is his or her homeostatic or dominant ERF. When an SSM and, consequently, an ERF of a video game's virtual environment is formed, the ERF may conflict with the user's PERF (i.e., homeostatic ERF), which, for the user, references his or her physical world. To experience spatial presence, the ERF, expressed as a user's psychological location within the game, must supplant his or her PERF. The perceptual hypotheses related to the current PERF and ERF are tested to determine which environment becomes the user's primary choice of location.

Two perceptual hypotheses are presented to the user while playing a video game. The *media-as-PERF* or, in the case of playing a video game, the *game-as-PERF* hypothesis posits that the virtual world of the game is the PERF, and the *reality-as-PERF* hypothesis posits that reality, i.e., the real world, is the PERF. The sensory evidence that is present and available to the user will lead to his or her acceptance of only one of the hypotheses. When tested, the *game-as-PERF* hypothesis may be accepted in lieu of the *reality-as-PERF* hypothesis.

Perception relies upon receiving, interpreting, and forming hypotheses about stimuli within an environment (Bruner & Postman, 1949 as cited by Wirth et al., 2007). Within Wirth et al.'s model, the *theory of perceptual hypothesis* is used to explain the process of evaluating

stimuli to form perception (Lilli & Frey, 1993). The formulation of perception is a three-step process in which an expectation hypothesis is formed, information about perception is incorporated, and the perceptual hypothesis is confirmed or disproved. During the first step, one's prior experience guides the hypothesis of expectation by discerning salient information. This expectation hypothesis affects the information perceived as well as potential alternatives. The expectation hypothesis is confirmed or rejected based upon present sensory information. Users who have played a specific type or particular video game form a game-as-PERF hypothesis and select and organize salient elements from the game environment to make judgments about the nature of their experience. Conversely, the game-as-PERF of individuals who have not played a specific type or particular video game may be weaker, making it less plausible. Wirth et al. (2007) suggest that a richer and more accurate SSM increases the strength of a game-as-PERF hypothesis in two ways. A stronger SSM adds consistency and plausibility to the game-as-PERF hypothesis; it makes it harder to reject. Perception is beneficially altered by a strong SSM, which increases the salience of a user's ERF; therefore, a user accustomed to a particular game or genre of games may be more likely to accept the perceptual alternative that leads to experiencing spatial presence within the game.

Spatial presence is realized and self-location is experienced only through continual acceptance of the game-as-PERF hypothesis and the rejection of the reality-as-PERF hypothesis (Wirth et al., 2007). Once the game-as-PERF perceptual hypothesis is repeatedly confirmed, self-location is experienced, and perceived possible actions are the only actions the user recognizes.

Stereo 3D, games, and the spatial presence model. When users play games with stereo 3D graphics, they experience the sensations of presence, spatial presence, and increased enjoyment (Ellis et al., 2011; Rajae-Joordens, 2008; Shafer, Carbonara, & Popova, 2011;

Takatalo et al., 2011). Video games rendered in stereo 3D provide users with superior visual detail that enhances the position of objects within the game environment (Bae, Lee, Park, Cho, Park & Kim, 2012). While enriched visual quality is afforded users, the current stereo 3D technology is not without some limitations.

Before stereoscopy in games is discussed, an important distinction should be drawn between 3D games and stereo 3D games. First-person shooter games are 3D games that rely on monoscopic cues to produce the sensation of depth. Salient monoscopic cues include *occlusion*, which is the blocking of background objects by closer objects; *structure from motion*, which allows the user to make judgments about a particular space by actively navigating through it; and *perspective*, which is constituted by the differing sizes of similar objects from various distances and the disparities in their textural qualities (Ware, 2008).

Games played on *stereo 3D displays* are capable of demonstrating both monocular and binocular depth cues. Stereo 3D displays provide a slightly different view to each of the user's eyes, which is processed visually to produce depth information (McIntire, Havig, & Geiselman, 2014). In most consumer stereoscopic displays, stereo 3D is accomplished in one of two ways, each of which has inherent problems. Using *passive technology*, the screen presents different images for the left and right eyes simultaneously. Polarization is used so that images are presented to each eye simultaneously, albeit only at half an image's vertical resolution. Stereo 3D that uses *active technology* is accomplished with specialized vision-blocking glasses, commonly known as active shutter glasses. These glasses are synchronized with screen images made viewable by only the eye for which the image is intended. As an image is displayed, the active shutter glasses rapidly obscure the view of one eye, allowing only the intended eye to view the image. In most cases, greater depth and realism are added to the media using this

technology; however, some shortcomings of current technology include the decrease of display resolution found in passive displays and the decreased frame rate prevalent with active displays. The apparatus section of Chapter III discusses the method by which this limitation was overcome to provide adequate display resolution and refresh rate for participants.

Several factors affect experiencing spatial presence within a video game, including level of interactivity between the user and the game, the nature of the tasks, and vividness of the media. Vividness is the number of visual sensory channels available: the more channels available and the better their resolution, the increased likelihood of experiencing presence (Steuer, 1992). Stereo 3D increases the depth contained within the available visual sensory channel thereby increasing the visual information presented to the user. Most video games are displayed on nonstereoscopic displays that use monoscopic cues to provide depth information to users. In 3D first-person shooter games, monoscopic cues supply the user with sufficient spatial information to navigate the virtual environment.

Although monoscopic cues can be sufficient for game play, stereo 3D is capable of increasing the visual fidelity of video games. Stereo 3D affects the reception of video game content in several of ways. It visually enhances video game content by emphasizing the foreground and background of the environment (Bae et al., 2012). Enhanced visual fidelity can make a first-person shooter game seem more perceptually pervasive and add to the user's sensation of realism when playing (Ribbons & Malliet, 2010). Bae et al.'s model suggests that playing video games in stereo 3D produces exceptionally realistic imagery of a virtual world and stronger egocentric representation that positively affect a user's report of presence.

Although Wirth et al.'s (2007) model does not directly include perceived realism within the construct, the quality of the media does affect the likelihood of experiencing spatial presence.

Wirth et al.'s conceptualization suggests that the sensory qualities of stereo 3D influence the process of spatial presence in three ways. First, when stereo 3D is used, more attention can be allocated toward the media, than when a nonstereoscopic display is used (Schild, LaViola, & Masuch, 2012). Rajae-Joordens (2008) examined the effects of stereo 3D game use on *skin conductance response* (SCR), a physiological variable associated with the experiencing of arousal, and found higher SCR when *Quake 3* (1999) was played in stereo 3D than when it was played in 2D. The increase in SCR in the stereo 3D condition was sustained for the full 45-minute duration of exposure; however, for the subjects who played in 2D, the SCR quickly returned to baseline levels, which suggests that stereo 3D is more arousing and can lead to sustained immersion. Grabe, Zhou, Lang, and Bolls (2000) suggest that media that is more arousing can increase attention directed toward it.

The use of stereo 3D leads to greater game involvement when the user processes content (Ellis et al., 2011). Wirth et al. (2007) define involvement as the “active and intensive processing of the mediated world” (p. 513). Attention is required for an SSM to be formed. High levels of involvement bind a user's senses to the media and can foster presence (Klimmt & Vorderer, 2003). When game users' cognitive involvement is high, their cognitive processing capacity is occupied at higher levels and they focus on the elements of the game. Increased immersion shifts users' focus less on the game's control hardware and mechanics; and more on the media experience. Greater cognitive involvement during game play strengthens the game-as-PERF hypothesis (Wirth et al., 2007).

Second, stereo 3D increases the quality of the SSM by increasing the amount of information represented within the visual channel. It provides additional spatial information about the objects and their locations within a virtual environment. The addition of this spatial

information assists with the formulation of an SSM of greater internal consistency and richness. When an SSM is more robust, it, too, strengthens the game-as-PERF hypothesis. Finally, stereo 3D provides additional perceptual support for the game-as-PERF hypothesis, which increases the likelihood that the game-as-PERF hypothesis is confirmed.

Video Games Pacing and Using Skills to Overcome Obstacles

Definitions of game pacing and its relationship to different aspects of a video game are presented. In this section, a brief review of pacing in video games is followed by an explanation of its use in shooter games. A review of the literature describes the competencies that video game users develop through frequent game use and offers insight to users' ability to process and overcome the challenges posed by fast-paced video game content. The effects of pacing and user game-playing skills are then then discussed relative to cognitive involvement and the spatial presence model.

Video game pacing. What is pacing in a video game? Within the literature, *game pacing* is defined and operationalized in various ways. Some descriptions of the term pinpoint the user's violent actions toward virtual actors within a game; other descriptions highlight the rate of interaction between the virtual actors and the user, that is, the number of situations presented that require an action from the user (Krcmar, Farrah, & McGloin; 2011; Myers, 1992). Yet other descriptions acknowledge the interactive nature of games by including the within-game rate of the user actions and other actor's actions (Jennet et al., 2008).

Different levels of pacing can be found at various levels of abstraction within a game. For example, at the global level, which considers only the content of a particular game, a tactical first-person shooter game such as *Rainbow Six* is characterized as slow-paced and tactical. As a tactical first-person shooter game, *Rainbow Six* typically presents the user with fewer enemies

within a single scenario and requires a cautious, methodical approach to dispatching them. The mechanics of this game require the user to move through scenarios slowly with more deliberate movements because a single shot fired by an enemy can “kill” the player’s game character. The pace of play in *Rainbow Six* can be contrasted with fast-paced games such as *Call of Duty*.

Games within the *Call of Duty* franchise are characterized as fast-paced because they provide the user with scenarios in which he or she is presented with a legion of enemies and an assortment of game play mechanics, including regenerating health that allows a user to “recover” rapidly to re-engage quickly on-screen virtual enemies.

Pacing can differ within a single game, changing at different levels throughout that game. A single video game can be segmented, for example, into chapters, stages, or levels. The pacing of these segments can differ from one to another. Some segments can require the user to employ a stealthy approach (slow-paced) in which the user does not engage virtual enemies in combat or complete a game objective in a clandestine manner. However, other segments of the same game can require the user to confront multiple waves of enemies at a quicker pace to complete an objective. Game segments can be divided further into a particular *state* or *scenario* in which a user is directly involved. Within a first-person shooter game, a user may be required to combat the enemies within a specific virtual space before entering the next state or scenario.

Conceptualizations of pacing. The pace of video games, as within first-person shooter games, is conceptualized and defined in various ways. Scholars examining physical aggression intention and verbal aggression have regarded video game pacing as a subjective evaluation of the user. For example, Krcmar et al. (2011) studied the user’s perception of pace by comparing play of an older game, *Doom 1* (1993), and a newer game, *Doom 3* (2004). Pacing was operationalized using a single, 7-point Likert-type item that asked the user to assess each game

as fast- or slow-paced. Adachi and Willoughby (2011) view pacing as a behavioral attribute. They defined the *pace of action* as the rate of violent acts perpetrated by the user against a virtual opponent within a shooter game. Myers (1992) describes video game pacing as the presentation of oppositions that a user must resolve within a state of play.

The concept of pacing is understood differently within the field of game design than within the social sciences. Some game designers view pacing as (a) the rate at which virtual opponents challenge a user and (b) the amount of difficulty presented by these opponents for the user (e.g., Pfeifer, 2004). Others suggest that pacing is more complex, comprising several aspects.

Davies (2009) describes four aspects of pacing within single-player action games. The first is *movement impetus* or the “push” of the game to move the player through the environment. Movement impetus can be increased to force the player to move more quickly within the game’s environment. For example, introducing virtual threats into the environment from behind the user to encourage forward motion, imposing time limits, or providing a smaller spatial environment to increase the likelihood that a user will move more readily throughout the game’s scenarios. A second aspect is *threats of danger*. Game features fabricated to increase the sense of danger a user experiences during game play actualize this aspect of pacing. Enemies approaching a user’s game character constitute a threat that must be addressed by the user. The proximity of a threat influences the user’s perception of that threat: the closer the threat, the more immediate the perceived danger, the quicker the required response. Within some games, *tension*, the third aspect of pacing is used. Tension reflects the perception of a danger within the environment. It is achieved through a variety of ways that include visual cues and sound effects to imply the presence of a nearby enemy or group of enemies. Two of these devices are blips portrayed by an

on-screen radar or ominous music played in a scene. A fourth aspect of pacing is the *tempo* or the amount of intensity in the action that occurs within the game.

Pacing defined. Defining pacing within a shooter game is a challenging task for two reasons: video games are interactive by design and game play is dependent on interactions between the game and user. Before an operational definition of pacing is proposed, several factors must be reviewed. First, the scenarios in video games are either *externally paced* or *self-paced* (Jennet et al., 2008). External pacing is the user's performance of tasks at a pace dictated by the game; self-pacing occurs when the user maintains control of the rate at which tasks are performed. Games within the shooter game genre offer a degree of both. Users of these games are required to confront obstacles such as virtual threats as external pacing; but are allowed some element of self-pacing to navigate the virtual environments. In many shooter games, virtual enemies are dispersed throughout the spatial environment, and in certain situations greater navigation of virtual space within a game can increase self-pacing since the user will encounter virtual enemies at a more rapid pace.

Optimally, the amount of external pacing regulating game content and the amount of self-pacing accepted within a scenario should be built into and constitute the actual pace of game play, a combination that is conceptually similar to Davies's (2009) concept of tempo of action. Since user behavior cannot be directly manipulated, external pacing is the only viable factor that can be manipulated within a scenario. Myers (1992) asserts that the pace of a video game increases by "rapidly presenting the player with oppositions to resolve within a singular context" (p. 448). While Myer's conceptualization of pacing has sufficient breath to be operationalized within the context of a shooter game, a definition should consider the oppositions rate and the space of the scenario. Within this study, pacing is defined as the number of virtual actors with

whom the user can interact in a spatial scenario within a defined period. An increased number of virtual actors within a given space subscribes to Jennet et al.'s (2008) concept of external pacing within shooter games. This definition of pacing allows users to experience what Davies describes as the threats of danger and tempo, since an increase in the number of virtual adversaries within a scenario also increases the rate that enemies can be encountered with the likelihood that multiple enemies are encountered simultaneously.

If a low number of virtual threats are present within a scenario, then the user is confronted with a relatively stable pace and modest degree of challenge; however, if the number of virtual enemies increases, then the rate of threats to which a user must respond also increases. The user likely is capable of engaging more enemies within a scenario, but must be wary of being assailed from all angles within the space of the scenario. The user must actively track the known threats, select a target, quickly dispatch it, then, rapidly transition to confront the next threat. While engaged with virtual threats, the user must survey the surroundings for emerged or emerging threats. To accomplish the goals of these fast-paced scenarios, a measure of skill is required. Users with advanced skills are better prepared to confront successfully challenges, while those users with fewer or less honed skills or no game-playing experience may not have the requisite ability to overcome obstacles presented in the game.

Some individuals develop a high level of game play competence with a particular game, a genre of games, or a subset within a genre; however, other individuals are incapable of demonstrating similar competencies. In what ways can differences between player competencies confound efforts to examine the effects on the processes that develop spatial presence? How does competency enhance a user's ability to handle increased pacing?

The traits of players possessing superior game-related competencies are discussed vis-à-vis the ways in which those competencies increase players' capabilities to perceive, process, and respond to increasing amounts of visual information presented in fast-paced content. Cognitive involvement and potential consequences of player competency and game difficulty are discussed.

Game play competence. Various qualities separate inexperienced game users from their more skilled counterparts. Many of the distinctions drawn among users of various skill levels are based upon content processing and interaction abilities. Individuals who demonstrate superior game-playing skills possess finely tuned motor skills, visual-processing capabilities, and learned tactics, each of which allows them to excel when processing and interacting with video game content. The discussion of skill includes the learned competencies derived from playing video games, the effects of action games on human visual processing, and the visual cognitive efficiencies gained from playing these games. The implications of learned competencies and visual processing are discussed in terms of their effects on the potential of cognitive efficiency attained by the player through shooter game use.

Learned game competence. Learning to play a video game presents challenges to inexperienced users. When learning to play, a user proceeds through three phases (Lindley & Sennersten, 2008). Within the first phase, a user develops *interaction mechanics*, that is, an individual's motor skills competency expressed with game controls manipulation. Interaction mechanics facilitates a user's unconscious manipulation of the control mechanism. During the second phase, a user proceeds through *interaction semantics* in which associations between the control mechanism and in-game actions form. The user learns game basics and is able to manipulate the control device to perform in-game actions; however, the user has not learned the situational applications of the in-game actions. In other words, the user does not know which

action to apply to a particular situation. During the third phase, *game play competence* is established. It is during this phase that the user is capable of selecting the proper in-game actions for situations faced in specific scenarios. Once a user has achieved game play competence, he or she can learn and execute tactics that demonstrate increased situational performance. The game-play tactics that a user is capable of executing derive from the use of *scripts*. Scripts are defined as mental concepts that connect causal links, goals, and action plans (Abelson, 1981; Schank & Abelson, 1977). Scripts influence interpretation and behavior that guide decision processes, attention management, and responsive motor actions during game use (Lindley & Sennersten, 2008).

A comparison of in-game performance and cognitive efficiency during game play reveals a wide disparity between individuals with low game play competence and those with high game play competence. Those with fewer game-playing skills may not have developed competency with the control device, possess the ability to execute the action, or understand the specific context in which they should initiate actions within a game. However, individuals with high game play competence use the control device with success to execute the actions of the game and through their use of scripts are able to activate quickly the proper action for the corresponding situation within a scenario. Competent users' activation of scripts yields greater efficiency within a specific scenario. It allows users to interpret rapidly the scenario, to retrieve an optimal course of action, and to use efficaciously motor skills to execute preferred courses of action.

Visual processing. Video games, by definition, rely heavily on interactive, visually stimulating presentations. Users must process and respond to the situational, interactive presentations that comprise game scenarios. Many of the visual components of video games that make them interesting and complex have evolved with an ever-increasing sophistication

throughout the span of the gaming industry. The stimulating graphics and imagery of action games (Greenfield, DeWinstanley, Kilpatrick, & Kaye, 1994) especially, those of first-person shooter games, can increase users' visual-processing abilities (Feng, Spence, & Pratt, 2007; Green & Bavelier, 2006b) that are invaluable while playing shooter games. Individuals who regularly play these games develop enhanced visual abilities that are exercised to confront increasingly complex scenarios such as faster pacing of virtual threats.

Green and Bavelier (2003, 2006a, 2006b) suggest that action video games, such as shooter games, increase the visual-processing capabilities of the games' regular users. It is believed that action game use affects either *bottom-up* processing or *top-down* processing or a combination of both. Bottom-up processing has its basis in the visual characteristics of the media. The literature reveals that users who frequently play action video games exhibit greater sensitivity to visual stimuli. For example, Li, Polat, Makous, and Bavelier (2009) determined that video game training led to an increase in study participants' sensitivity to contrast. Other investigators note that action games increase users' spatial resolution, that is, they have the ability more so than non-game users to perceive objects' proximities to one another (Green & Bavelier, 2007).

While action game users are better able to process on-screen visual stimuli, they also are more capable of identifying and filtering out distracting stimuli using attention. Top-down processing has its basis in attention, the demands of the tasks, or a combination of both. The acquisition of highly specialized top-down processing skills has definite benefits for shooter game players. These benefits include (a) increased visual attention, which facilitates recognition of salient stimuli within cluttered environments (Green & Bavelier, 2007); (b) intensified attentional dynamics, which supports more rapid attendance to subsequent stimuli following the

introduction of the initial stimulus (Green & Bavelier, 2003); (c) greater resolution of spatial attention, which enables the simultaneous tracking of several visual objects (Boot, Kramer, Simons, Fabiani, & Gratton, 2008; Green & Bavelier, 2006c); and (d) use of broader search patterns, which permits on-screen changes to be perceived at lower thresholds more readily (Clark, Fleck, & Mitroff, 2010).

Both top-down processing skills or the bottom-up processing skills can improve a user's visual-cognitive efficiency, boosting the speed by which game events are perceived and scripts are incorporated for rapid, appropriate responses to virtual threats. Lee and Kim (2008) suggest that a degree of cognitive processing capability is required before an individual can experience spatial presence. How is cognitive load measured and do the attributes of users with more game-related competencies yield more available cognitive resources?

Player skill and cognitive load. Typically, the level of an individual's cognitive load is examined indirectly by measuring an individual's available attentional resources. This measurement requires a user to execute both primary and secondary tasks. If the difficulty level of a primary task varies, then the amount of attention allocated to secondary tasks varies as well. If the difficulty of the primary task increases, then fewer attention resources are allocated to the secondary task; however, as the primary task becomes less difficult more attention can be allocated to the to the secondary task.

More cognitive resources are allocable when a user has high game play competence. Because shooter game users have greater visual-processing ability and high game play competence, they can interact with and process video game scenarios while maintaining adequate attention resources to complete the distractor task in the study, which is a secondary task designed to measure attentional resources available to a participant (Maclin, Mathewson,

Low, Boot, Kramer, Fabiani et al., 2011; Green & Bavelier, 2003; 2006b). Green and Bavelier (2003) measured allocable attention of participants playing a shooter video game. They determined that as the difficulty of the task increased, the allocable visual attention of action game players remained relatively constant; however, the allocable visual attention of non-players decreased. The findings from Green and Bavelier (2006c) were similar: action game users' visual attention and performance were greater across the experimental conditions than were the visual attention and performance of non-players.

The effects of cognitive load during media use are examined with other methodologies as well. Electroencephalography (EEG) is a tool that allows an investigator to examine amounts of available attention resources using physiological data. Macklin et al. (2011) examined the *event-related potentials* (ERP) and *event-related spectral perturbations* (ERSP) by synchronizing both with the tasks of a space flight simulator game and a distractor stimulus using EEG measurements. After 20 hours of training, the participants' neurological responses to the tasks and a distractor indicated that participants required fewer cognitive resources than were required prior to the training, which suggests that they achieved a degree of competency with the space flight simulator game.

The complex situations presented in video games require players to possess skills for manipulating controls, understanding how to perform in-game actions, and applying them within the contexts of their appropriate uses. In addition, fast-paced video games require a special set of visual-cognitive skills that aid players with perceiving, tracking, and interacting with numerous objects within a scenario. As users' levels of game-specific competency vary so can their experiences with the content. When users with high game play competence and high degrees of visual-cognitive skills play a fast-paced game that presents a challenge to them, a state of intense

involvement or *flow* may be experienced (Csikszentmihalyi, 1990). Flow occurs when a player's level of skill matches the game's presenting challenges. Conversely, if users do not have requisite skills to compete with fast pacing and increasingly difficult tasks and decisions, then they are unlikely to experience flow, and they can become cognitively overburdened.

Limited Capacity Model for Motivated Media Message Processing (LC4MP)

LC4MP is a paradigm that can explain video game content processing relative to skill level variability. It also explains motivational relevance as a factor that can increase or decrease processing of the media. Three sub-processes are described. The concept of motivational activation is discussed in general and with specific reference to video games.

Limited capacity. Cognitive capacity is required to process mediated content. There are two assumptions in the application of *LC4MP* (Lang, 2000, 2005). First, people are information processors; they perceive stimuli from their environment, perform work to turn the stimuli into mental representation, and reproduce the information in some form. Second, cognitive resources are required to process information; however, an individual's cognitive resources are limited.

Sub-processes. Three sub-processes are associated with information processing: *encoding, storage, and retrieval* (Lang, 2000). Encoding begins with the acquisition of information through sensory reception. Goals, knowledge, and the environment shape the visual information collected from media content. During encoding, information selection can occur through *automatic processes*, which are unintentional; and *controlled processes*, which are intentional. Several qualities of the media affect automatic processes. They include novelty, change, and intensity (Lang). Controlled processes are guided by the user's goals. Both automatic and controlled processes are used to construct a mental representation within working memory.

During storage, connections are formed between new information and old information. Increased deliberation about new information supports stronger association with old memory structures. The sub-process of retrieval facilitates the query and activation of previously stored memories, which vary in strength. The greater the number of associative linkages created between new information and a memory structure, the more easily older information is retrievable.

Motivation systems. LC4MP posits that two oppositional systems, *appetitive* (approach) and *aversive* (avoidance), affect encoding, storage, and retrieval (Lang, 2005). The appetitive system sustains or preserves the individual; the aversive system protects the individual from harm. Different emotional states drive the activation of each system. Appetitive system activation is associated with positive emotion, and aversive system activation is associated with negative emotion. The systems are employed as follows: (a) no system is activated, (b) either system is activated, or (c) both systems are simultaneously activated, i.e., *co-activation* (Caccioppo, Gardner, & Bernston, 1999; Lang, 2000; Lang, Shin, & Lee, 2005).

Activation of the motivation systems affects information processing. When a stimulus is motivationally relevant, cognitive capacity is allotted for encoding, increasing the likelihood that the stimulus will be encoded (Lang, Bradley, & Cuthbert, 1997). Motivationally relevant stimuli include the structural features of media such as speed, intensity, novelty, and its degree of positive or negative valence. Aversive system activation can, at the onset, lead to an increase in the allocation of cognitive capacity to encoding and storage; however, after an adequate amount of information is collected, cognitive capacity for storage allocation is decreased and routed to the preparation of a fight or flight response (Lang, 2005).

Motivated activation and video games. From the LC4MP perspective, the *old brain* processes media as reality, responding to it quickly in preparation for a fight or flight response. Lang (2005) asserts that “intense or fast onset stimuli” (p. 11) trigger defensive or startle responses. Such responses are salient because attention is quickly allocated before stimuli are processed by the higher-level cognitive areas of the prefrontal cortex. The *new brain* is associated with higher-level cognitive functions and reacts differently to the media. Higher functions within the new brain inhibit responses by the old brain and discount the perspective presented by the media; however, the new brain demonstrates significant response latency in this process. The new brain reacts to stimuli much more slowly than the old brain. Whereas the old brain triggers a startle response within the first few hundred milliseconds, the new brain may not react for as many as 1,000 milliseconds (Lang, 2005). For example, some events within a video game may be initially interpreted by the brain as being real within the first few hundred milliseconds; however, once the new brain processes the stimuli it suppresses the initial response of the old brain discounting the realism of the particular event.

Lang (2005) contends that use of video game content leads to co-activation of the aversive and appetitive systems. Although video games are not based in reality, the level of graphical realism is sufficient to evoke responses from an individual. Video games with greater fidelity provide realistic cues that are perceptually difficult to discount. Lang states,

Thus, to the extent to which a mediated stimulus has a greater match with the real world, it likely will elicit a coterie of automatic physiological, psychological, and perhaps even behavioral responses. Therefore, the task of inhibiting the old brain and body may be a bigger job. (pp. 11-12)

When visual cues, such as stereo 3D are present, the old brain is less inhibited. During video game use, violent content increases aversive activation. However, since the new brain is conscious that video games are not of the real world and exist for enjoyment, appetitive activation is present. The more natural the appearance are of images within video games, the greater the variance of aversive activations among different users. Frequent shooter game users may seek an immersive experience, while those who dislike violent games will avoid graphic content.

First-person shooter game users have greater affinity for game content, which increases a game's motivational relevance. Lee and Kim (2008) suggest that cognitive resources must be available for spatial presence to be experienced. Through repeated use, frequent shooter game users increase their skill levels and visual-cognitive efficiency, which permits the requisition of fewer resources during complex game situations. If an individual is uninterested in a shooter game, then the game becomes less motivationally relevant. Hence, those who do not enjoy playing shooter games may be neither motivated nor able to process the media in its entirety, especially when increasingly complex situations are present (Lang, 2005).

Synthesis of Theory

The following synthesis attempts to reconcile the propositions of the spatial presence model with LC4MP. The effects and theoretical considerations of resolution, stereo 3D, game-player competence, novelty, and previous game experience are discussed within the conceptual framework of this study. Hypotheses and research questions are proposed.

Attention and selection. A user's attention must first be directed toward the media if he or she is to perceive and engage the game. Video game features increase both the uncontrolled and controlled attention of the user. According to the spatial presence model, uncontrolled attention

is attained through the structural aspects of the media. LC4MP broadens this proposition by asserting that through uncontrolled attention what is perceived is determined through a user's orienting response (Lang, 2005; Lang et al., 1997). These propositions imply that structural features, such as stereo 3D, can generate greater levels of attention to be focused on the media while a user plays a shooter game.

Factors such as movement, novelty, and change can prompt some aspects of the game to be emphasized by the user more so than others. For example, virtual enemies introduced into an environment can cause an initial orienting response; however, those threats also offer the dynamics of environmental novelty and change eliciting additional uncontrolled attention. When attention is focused on virtual threats, greater visual attention and cognitive resources are required from users with low game play competence. If only low amounts of visual attention are available, then salient spatial information cannot be fully perceived or processed.

Interest and goals. Media content affects controlled attention. An individual's level of domain specific interest (DSI) may increase the amount of controlled attention allotted to content (Wirth et al., 2007); however, the individual's goals also determine which aspects of the media are encoded (Lang, 2000). Individuals with high DSI for a particular genre of game and greater appetitive system activation will choose to allocate more of the attention resources to that specific video game. In addition to devoting more resources to that game, users who play the game competently possess refined goals. Those goals can lead to greater processing of the virtual environment. For example, users with high game play competence may survey their surroundings for "cover" to protect them from enemy fire and may examine the environment more carefully for other enemy threats. Hence, the spatial features of the environment can become more salient to those with high game play competence.

Sub-processes, scripts, and efficiency. Cognitive allocations can fluctuate and affect the processing of the media. Allocations to encoding, storage, and retrieval constantly fluctuate and differ based on the user's strategic decisions and actions during game play. A user's level of game play competence can affect the availability of cognitive resources in several ways. First, if competency with the control mechanism is low, then cognitive resources can be directed to information storage. Information about the control mechanism and its functions can be retrieved and learned (Lang, 2005). Competence is developed by learning to use the control mechanism, mastering the use of in-game actions, and understanding the context in which in-game actions should be performed (Lindley & Sennersten, 2008). Individuals with low game play competence endure trial and error attempts while learning to manipulate the control mechanism. They expend conscious, cognitive effort to learn to manipulate the controls. This effort leads to an increase in cognitive resources that must be devoted toward storage and retrieval. Users with high game play competence are able to effortlessly perform in-game movement and actions thereby producing greater cognitive efficiency because in-game control information is unconsciously retrieved and applied to action decisions. Scripts also are formed through frequent game use. These scripts, when retrieved, are used to respond to virtual threats within the game (Lindley & Sennersten, 2008). Scripts allow greater cognitive efficiency because less effort is required to interpret and respond to the situations presented by the game.

A user's level of game play competence within a particular game should directly affect the sub-processes of encoding, storage and retrieval and, consequently, the cognitive resources available. Since users with minimal game play competence allocate large amounts of resources to storage and retrieval of information, which pertains to game strategy and performing actions, cognitive-processing capability becomes limited. Users with high game play competence allot

fewer resources for the functions of encoding, storing, and retrieving information to navigate the environment, perform actions, and implement tactics.

Game play competence and SSM construction. A user who is able to access more cognitive resources can allocate resources toward encoding, storage, and retrieval to process salient features within a virtual environment. Researchers contend that high game play competence can facilitate construction of a strong SSM and can lead to the experiencing of spatial presence (Wu, 2010). The literature suggests that a game user's level of competency is strongly correlated to the construction of a strong SSM. Wu discovered that self-reported player skill level is strongly and positively correlated with SSM strength. High game play competence may influence the formation of an SSM in two ways: (a) by yielding greater cognitive efficiency, which supports the reallocation of unused resources, and (b) by allowing greater controlled movement through the virtual environment. Such movement is useful for structure through motion, which provides an additional depth cue. A greater capacity to navigate and process the salient features of the virtual environment by a user make it more likely that the features of the environment will be assimilated into a strong SSM.

Individual traits. Traits such as visual spatial imagery (VSI) and game-specific knowledge affect the construction of the SSM. High levels of the VSI trait increase the saliency of spatial cues and assist the user with their construction of their SSM (Wirth et al., 2007). VSI facilitates the assimilation of spatial cues into an SSM when cognitive resources are available. Although an SSM is formed with spatial cues, empty slots exist within the SSM (Wirth et al.). These empty slots enable prior spatial knowledge to be added to the SSM. Users who have game-specific knowledge can enrich the SSM by readily retrieving and applying it to the empty slots within an SSM. Although ample spatial cues can be present, those who have less game-

specific knowledge do not possess the library of information of the domain and, therefore, do not construct SSMs that are more robust.

Pacing. Pacing in a video game is operationalized differently based upon genre. One definition of pacing in a video game is the rate at which users must react violently to virtual enemies. This definition can be extended to include the rate at which a user must confront those enemies (Myers, 1992). Pacing introduces complexity and challenge into game play. As it increases, allocable cognitive capacity can decrease under certain circumstances. If pacing increases from slow to fast, then individuals with high game play competence should require fewer cognitive resources. Fast pacing should be negatively correlated to the construction of an SSM and experiencing spatial presence for users with low game competence because they require greater cognitive resources while playing the game. A slow-paced game may not be so taxing for users with low game play competence; however, if too many virtual threats are introduced, then, they may become overwhelmed or cognitively overloaded, which could lead to inadequate cognitive resources for processing the media (Lang, 2005). If pacing of a video game is fast and the user has the requisite competency and retains adequate processing capability, then an experience of immersion or cognitive involvement can lead to even greater attention allocated toward the game.

Processing capacity and perceptual hypotheses. High game play competence leads to additional cognitive resources that strengthen the SSM. Once an SSM is formed, an egocentric frame reference (ERF) is constructed as well. The strength of the SSM contributes to the strength of the ERF and perceptual hypothesis. If adequate processing capacity is available and salient visual cues are present, then the game-as-PERF hypothesis can be strengthened. However, if adequate processing capacity is not available, then salient visual cues may not strengthen the

game-as-PERF hypothesis. The user may not easily accept a weakened media-as-PERF hypothesis as the PERF (Wirth et al., 2007).

The strength of the SSM directly affects the ERF and the experiencing of spatial presence. When an SSM is weak, it has a negative effect on the game-as-PERF hypothesis, which requires a greater amount of confirmatory information to support it and less contradictory information to reject it. When the SSM is robust, the likelihood of the game-as-PERF hypothesis is increased. After a robust SSM and a strong game-as-PERF have formed and the verisimilitude of the sensory information is supportive, the media-as-PERF hypotheses is confirmed. As the media-as-PERF hypothesis is continually confirmed during game play spatial presence is experienced.

Hypotheses of the Study

Stereo 3D facilitates the spatial presence in primarily in three ways: (a) stereo 3D graphics increase attention directed toward the content; (b) stereo 3D is a depth cue that can be used to construct and enrich a game user's SSMs; and (c) additional visual information used to construct the SSM supports the game-as-PERF perceptual hypothesis, which leads to the experiencing of spatial presence. Therefore, the following hypotheses are proposed.

H₁: Participants will form stronger spatial situation models when exposed to stereo 3D stimuli than when exposed to 2D stimuli.

H₂: Participants will experience greater spatial presence as (a) self-location and (b) perceived possible actions when exposed to stereo 3D stimuli.

The literature in the field suggests that skill can facilitate the experiencing of presence. Wu (2010) discovered that self-reported player skill had a strong positive relationship to the richness of the SSM that was formed. High game play competence affects SSM construction and

the experiencing of spatial presence in two ways. Game play competence provides the users with visual and cognitive efficiencies, which enable the judicious allocation of cognitive resources. Game play competence also supports the user's controlled movement through the environment, which facilitates presence by structure through motion. Lee and Kim (2008) assert that lower amounts of free cognitive capacity can inhibit the experiencing of spatial presence. High game play competence should promote adequate processing of the media and lead to the construction of a strong SSM and the experiencing of self-location.

H_{3a}: Participants with high game play competence will form more robust spatial situation models than those with low game play competence.

H_{3b}: Participants with high game play competence will experience greater self-location than those with low game play competence.

H_{3c}: Participants with high game play competence will experience greater perceived possible actions than those with low game play competence.

Action game users have greater allocable resources than non-action game users. Those additional resources can be directed toward forming stronger SSMs and, coincidentally, the experiences of greater self-location and perceived possible actions. Users with less experience with the game may not be able to process content efficiently. As such, they would gain little benefit from game play with stereo 3D stimuli. Therefore, when stereo 3D graphics are present:

H₄: Participants with high game play competence will form a stronger spatial situation model when exposed to stereo 3D stimuli than when exposed to 2D stimuli.

Stereo 3D provides a better representation of virtual landmarks and objects. Although 2D graphics afford adequate spatial cues to some users, the cues created by stereo 3D graphics reinforce the SSM and the game-as-PERF hypothesis. A strong SSM is essential for an

individual's experience of spatial presence. Without SSM strength, the game-as-PERF hypothesis is weak and more perceptual evidence is demanded for its acceptance (Wirth et al., 2007). Users with low game play competence are not expected to develop a robust SSM; therefore, it is not likely that those users will experience spatial presence.

H₅: Participants with high game play competence will experience greater self-location when exposed to stereo 3D stimuli than when exposed to 2D stimuli.

H₆: Participants with high game play competence will experience greater perceived possible actions when exposed to stereo 3D stimuli than when exposed to 2D stimuli.

When adequate resources are available, stereo 3D can strengthen the SSM and provide rich sensory information that increases the strength of the perceptual hypotheses. Fast pacing should increase the resources required for successful play by users with low game play competence because they lack the visual and cognitive efficiency of more competent game users. Although spatial cues are displayed in the game scenarios, users' lack of processing capacity would diminish their processing of the spatial environment and decrease the possibility for experiencing spatial presence. Users with high game play competence are more visually and cognitively efficient. These efficiencies lead to the availability of allocable resources, the formation of a stronger SSM, and the experiencing of spatial presence. As pacing with the game increases, so should the cognitive involvement of skillful players, which contributes to both their appetitive response to the game and their willingness to accept the game-as-PERF hypothesis. However, increased pacing requires additional cognitive overhead for participants with low game play competence resulting in the decreased strength of the SSM and poor performance that could add to users' frustrations. These actions could contribute to an aversive response with a concomitant reluctance to accept the game-as-PERF hypothesis.

H₇: There will be an interaction between stereo 3D, pacing, and game play competence on the strength of the spatial situation model, experiencing self-location, and perceived possible actions. High-GPC participants playing a high-paced, 3D action video game will (a) form stronger SSMs, (b) experience greater sense of self-location, and (c) perceive more possible actions than will high-GPC participants playing the game with the other experimental conditions.

Low-GPC participants playing a low-paced, 3D action video game will (a) form stronger SSMs, (b) experience greater sense of self-location, and (c) perceived more possible actions than will low-GPC participants playing participants playing the game with the other experimental conditions.

CHAPTER III

Methods

Design

A mixed 2 (stereo 3D vs. 2D nonstereoscopic [within]) x 2 (high-paced vs. low-paced [within]) x 2 (high-skill vs. low-skill [between]) design was used to examine the effects of stereoscopy, pacing levels, and GPC on the process within the spatial presence model. For the stereoscopy condition, participants played a series of short video game segments, which were rendered at 1080p (i.e., 1920 x 1080 pixels). Within stereoscopic 3D study conditions, a stereoscopic 3D rendering software was activated and used to create stereo 3D graphics. During each of these sessions, pacing was manipulated: participants played against either one virtual combatant in the low-paced condition or against six virtual combatants during the high-paced condition. Each condition was established within the same in-game environment.

Participants

Recruitment of participants and data collection occurred during Spring, 2013 at a large southern university. The participant pool consisted of *Institute for Communication and Information Research* (ICIR) participant pool members, who were enrolled in a 100- or 200-level communications course. Fifty-seven subjects ($n = 57$) participated in the study. The investigator recruited subjects by posting an announcement of the study on a departmental recruitment website and publicized it by placing fliers at various locations in the school building. For their participation, students received a course credit toward a research requirement.

The number of participants of each gender was fairly balanced, with slightly more males (56%) than females (44%) participating in the study. The ethnic breakdown of the sample was as follows: 74% were Caucasian, 16% were African American, 7% were Hispanic, and 3% were Asian or Pacific Islander. The class year classifications of the subjects were 32% freshmen, 37% sophomores, 19% juniors, and 7% seniors. Overall, few participants reported heavy video game use; 42% of the participants reported not playing any video games throughout a typical week, 30% played one to three hours a week; 28% of the participants played four hours or more per week, and only 7% reported playing more than 10 hours a week. Subjects' familiarity with stereoscopic 3D media usage was assessed by their reported number of 3D movies watched and their self-report of playing video games in 3D prior to participation in the study. The mean number of 3D movies watched by the sample population was 5.47; 9% of that population reported playing a video game in stereo 3D.

Apparatuses

Monitor. The 3D TV models available to consumers that use active display technology for high-resolution graphics in stereo 3D that decrease the frame rate of a game by 60%, which greatly decreases graphical smoothness. Televisions that use passive technology decrease the display resolution by 50%. Because of the inherent bandwidth limitations with the HDMI 1.4a standard a decision was made not to use the current 3D television standard, HDMI 1.4; therefore, Samsung S27A750D, 27-inch widescreen, active 3D 120 Hz monitors were used for this study. The rationale for using the Samsung S27A750D was its DisplayPort 1.2 interface, which allows a comparison between stereoscopic and nonstereoscopic 1080p images at similar frame rates. When 1080p stereo 3D images are transmitted through the HDMI 1.4a standard, they are limited to a temporal resolution of 48 Hz or 24 Hz per eye. When images are displayed at 24 Hz, a single

image is displayed on the screen once every 41.67ms. When images are displayed at 60 Hz, a single image is displayed once on the screen every 16.67ms. When playing a fast-paced game at the slower screen refresh rate of 24 Hz, the display is updated less frequently, which can lead to game play appearing less smooth. Since the display is updated less frequently, it also takes more time for the screen to display the actions initiated by both the user and opponents. These factors can cause a user to experience greater latency during game play and negatively affect the feedback loop between the user and the game. The Display Port 1.2 interface permits the monitor to produce 1080p stereo 3D images at a temporal rate of 120Hz or 60 Hz per eye on active stereo 3D display devices.

Computer hardware. Two computers were selected for use in this study based upon the additional hardware requirements for rendering stereo 3D graphics and presenting stereoscopic stimuli to the participants. Each computer used Windows 7 as an operating system. The investigator rigorously tested each computer to ensure the adequacy of the operating system. This was accomplished by adjusting settings to ensure that each system and computer was capable of producing the desired frame rate. Both computers were used to render nonstereoscopic and stereoscopic 3D graphics. The first study computer was a desktop computer with the following specifications: i5 2500k processor, 8 gigabytes of high speed RAM, and an AMD Radeon 7970 graphics card. A second study computer was used so data could be collected from two participants simultaneously. That computer was an Alienware M17X R4 laptop with an Intel i7 3820QM processor, AMD Radeon 7970m graphics card, and 8GB of ram. Each of the computers was equipped with DisplayPort 1.2 ports.

3D software. *TriDef 3D Ignition* is a part of the *TriDef 3D* software suite used to convert two-dimensional (2D) into three-dimensional (3D) renderings that functioned as the stereoscopic

stimulus material for the study. *TriDef 3D Ignition* is a middleware program that is compatible with direct X 9, 10, and 11 computer games and is capable of producing stereoscopic images from games that do not provide stereoscopic support. The software supported a variety of output options; however, to enable 120 Hz, the output option was set to AMD HD3D technology.

Controller emulation software. Since the software used for the training session did not support any control peripherals, a controller emulation software called *Xpadder* was used. The investigator used *Xpadder* to map the keyboard and mouse controls to the Xbox 360 controller during the training session. The control schemes for the controller during the training and game-playing sessions were identical; however, the controller emulation software was disabled during the game-playing sessions because the video game played in the study had native support for the Xbox 360 controller.

Control mechanisms. Each participant was allowed to select the control mechanism he or she wanted to use for the duration of the study. Small posters that displayed how to initiate in-game actions using the chosen control mechanism were provided for the participants to reference during the study.

Keyboard and mouse. A standard-sized, 104-button keyboard and three-button laser mouse were one of the control mechanisms available to participants. The mouse and keyboard were connected via USB cable to the computer.

Xbox 360 controller. Participants had the option of using a Microsoft Xbox 360 controller. This controller is wireless and connects to a computer with the use of Microsoft Wireless controller adapter through a USB port.

Video Game Training

Each participant had to undergo a brief session of video game training. Although the duration of the training sessions was dependent on participants' level of skill, training sessions typically lasted from 5 to 10 minutes. Activision's *Call of Duty: Modern Warfare 2* was the game selected for training purposes. *Call of Duty Modern Warfare 2* is a popular first-person shooter, military-themed video game, and since its initial release, it has sold more than 22.4 million copies worldwide for the Xbox 360, PlayStation 3, and personal computer (Vgchartz, 2014). *Call of Duty Modern Warfare 2* was selected for training and evaluation prior to subjects' exposure to the experimental stimuli for three reasons. First, the *Call of Duty* franchise is one of the highest-grossing franchises and most popular first-person shooter, military-themed video game. Second, the game's mechanics and engine were only slightly different from the game used in the experimental conditions of this study. Third, it included a task-based tutorial and a performance assessment scoring method that consisted of counting the number of targets hit and recording the elapsed time during an in-game obstacle course.

The first chapter in the game, *S.S.O.D.*, was used for participant training. It consisted of a brief tutorial and user readiness assessment that was based on the amount of targets that a participant hit and the time elapsed as participants navigated the obstacle course. The tutorial commenced with weapons training at the in-game firing range. The session then demonstrated the performance of basic functions such as looking around, aiming, firing a weapon, and throwing a grenade. Participants were required to practice movement and navigation to locate the next area of the training grounds, which housed the obstacle course. When the participant arrived at the entrance to the obstacle course the training session continued and the tutorial illustrated additional skills, such as exchanging a current weapon for another within the environment,

switching among weapons in the player's arsenal, and reloading the current weapon. To fulfill the S.S.O.D. tutorial tasks, a timed obstacle course had to be completed. Upon the participant's completion of the obstacle course, the game displayed the elapsed time and the number of enemy targets hit.

Video Game Stimuli

Call of Duty: Black Ops was another successful addition to the *Call of Duty* franchise. It sold 28.7 million copies (Vgchartz, 2014) and was used in this study for its success as well as for the success of the franchise. There were two additional reasons for selecting *Call of Duty: Black Ops*. First, since the games were very similar in terms of graphics and game mechanics and controls, it was assumed that the skills to play one game would be easily transferable to the other. In this case, from the training session of one game to the experimental conditions presented through the other game. Second, *Call of Duty: Black Ops* had additional features that facilitated the manipulation of pacing. The multiplayer training mode that accompanied *Call of Duty: Black Ops*, allows players to customize their settings, including the environment in which they would like to play, the number of players, and the type of game (i.e., death match, team death match, retrieval). The multiplayer mode also allowed the addition of artificial intelligence computer bots against which the user would compete.

A map named *The Summit* was selected for use in each of the experimental conditions. The setting for the location of this map was a snowy mountaintop plateau. It included a large building with multiple entrances, several smaller buildings, and outdoor areas through which there were various paths and obstacles. The Summit was selected for two reasons. First, it represented the smallest map available that nevertheless offered a reasonable spatial area for exploration. Second, there was not a wide disparity between the contrasts of the environment,

characters, and objects. As such, by having less disparity in the contrast the potential for image cross-talk or ghosting, which appears as double images on some active stereo 3D displays, was decreased.

Each participant was the only human player in his or her multiplayer match. In each of the conditions, pacing was varied by altering the number of computer bots confronting the user. When multiple bots were present, they were programmed as a single opposing team so that they would only attack the participant's game character and not one another. The game setting used for the bots was *recruit*, which is the least difficult. The multiplayer matches in each condition were fixed for three minutes. Each time the participant's character was killed, it would re-appear within the game environment after a several seconds, which allowed the user to resume play for the duration of the match. When the participant killed a bot, the bot, too, would re-appear within the game environment within several seconds.

The difficulty setting used to control the artificial intelligence of the bots in the experimental conditions of this study was fixed at the lowest available setting. There were two reasons for this decision. First, the intention of the manipulation was to examine the effects of varying rates of bot encounters and not necessarily their increasing difficulty. Second, the investigator wanted to ensure that bots would not be too difficult for participants with such wide-ranging game-playing skills. The investigator did not want the high-GPC group to experience a flow-like state that could confound the results; therefore, pacing was manipulated by solely increasing the number of bots. Bots were limited to six presented simultaneously in the high-paced conditions due the processing power required of the computers to maintain an acceptable frame rate.

Low pacing. During the low-pacing conditions, participants encountered only one bot at a time. Since participants were faced with a single opponent at a time within the virtual area of the summit, there were fewer skirmishes, and the participant was less likely to encounter the bot. This permitted greater exploration of the virtual area within the game.

High pacing. During the high-pacing sessions, participants were capable of encountering from one to six bots simultaneously. Because more bots were present within the virtual space, participants playing the game in the high-paced conditions encountered more bots more frequently and were required to take decisive actions quickly or risk being killed.

Assessments and Measures

Previous Call of Duty: Black Ops experience. A single Likert-type item was used to inquire about participants' previous exposure to *Call of Duty: Black Ops*. This item was operationalized by using a single question: "Concerning the game *Call of Duty: Black Ops*, I have. . . ." Participants were asked to select one of five responses, which ranged from 1 (*I never played it before.*) to 5 (*I have played it frequently.*).

Previous 3D exposure. Obrist, Wurfhofer, Förster, Meneweger, Grill, Wilfinger et al. (2011) suggest that prior exposure to 3D content affects the experiences of presence when viewing stereo 3D content. Within their investigation, the authors used the number of 3D movies previously watched as a measure of previous exposure. Prior 3D exposure was ascertained from responses to two questions. The first asked participants if they had watched 3D movies. Participants were instructed to write the number of 3D movies watched in the blank space provided next to the question. The second asked participants if had played any video games using a 3D monitor or 3DTV. They were asked to select either a *yes* or *no* response to the question.

Game play competence. The training course contained 24 enemy targets and 11 civilian targets. A maximum of 160 seconds was allotted by the game for obstacle course completion. Within the *Call of Duty: Modern Warfare 2* training course S.S.O.D. chapter, the game records the time elapsed and the shooting accuracy of a participant. The game's internal scoring mechanics determine the difficulty level at which the user should play the game: easy, medium, or hard settings.

Although, the game play competence score that distinguished skilled play from unskilled play was derived from the time elapsed on the obstacle course and number of targets hit, the score itself was determined arbitrarily. This arbitrary delineation score was derived from an approximation of the performance thresholds established by the game, whereas a game difficulty level setting was suggested for the user. This score was approximated through trial and error. If the performance threshold of hitting approximately 24 enemy targets and no civilian targets within 90 seconds is reached, then the game suggests that the user proceed to the main campaign at the medium difficulty setting. If a user does not achieve the performance threshold, then the game suggests that the user play the game at a lower difficulty level. The delineation score that distinguishes between high- and low-game play competence was determined using the following equation: $(actual\ time) / (\#\ of\ targets\ hit)$, in this case, $90/24 = 3.75$. A participant was placed into the high-GPC group when he or she was capable of hitting one target within an average of 3.75 seconds or less. A participant was placed into the low game play competence low-GPC group if his or her average score was greater than 3.75 seconds per target.

Visual spatial imagery. The four-item version of the MEC-SPQ visual spatial imagery scale was used to measure participants' ability to visualize and recreate a mental representation of spatial structures (Vorderer et al., 2004). The Likert-type scale included items such as "When

someone describes a space to me, it's usually very easy for me to imagine it clearly," and "It's easy for me to negotiate a space in my mind without actually being there." Participants were asked to select one of five responses ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The Cronbach's alpha reliability for the scale was 0.73.

Spatial situation model. The four-item version of the MEC-SPQ spatial situation model scale was used to assess the strength of participants' SSMs (Vorderer et al., 2004). Example of the items contained in the Likert-type scale include, "I was able to imagine the arrangement of the spaces in the game very well," and "Even now I still have a concrete mental image of the environment." Participants were asked to select one of five responses ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The Cronbach's alpha reliability for the scale was 0.83.

Self-location. The four-item MEC-SPQ self-location scale was used to examine sense of self-location, the first dimension of spatial presence (Vorderer et al., 2004). The self-location scale was used to measure the degree to which an individual's media-as-PERF hypothesis is confirmed. Examples from this Likert-type scale include, "I felt as though I was physically present in the environment," and "I seemed as though I actually took part in the action of the game." Participants were asked to select one of five responses ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The Cronbach's alpha reliability for the scale was 0.89.

Perceived possible actions. To measure the second dimension of spatial presence, the four-item version of the MEC-SPQ possible actions scale was used (Vorderer et al., 2004). This scale measures participants' perceptions of possible actions during game use. Sample items used on this Likert-type scale include, "I had the impression that I could be active in the environment of the game," and "The objects in the game gave me the feeling that I could do things with

them.” Participants were asked to select one of five responses ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The Cronbach’s alpha reliability for the scale was 0.80.

Cognitive involvement. The four-item version of the MEC-SPQ cognitive involvement scale was used to measure participants’ perceived cognitive involvement during the experimental conditions. Sample items used on this Likert-type scale include, “I thoroughly considered what the things in the game had to do with one another,” and “I thought most about things having to do with the game.” Participants were asked to select one of five responses ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The Cronbach’s alpha reliability for the scale was 0.71.

Pretesting

While many of the questionnaire items were derived from validated scales, three pre-exposure questionnaire items were created or adapted by the investigator. These items were the *Call of Duty: Modern Warfare 2* prior experience, the 3D movie prior experience, and the 3D game prior experience items. A pretest was conducted prior to data collection to ensure that the training session constituted an appropriate tutorial for teaching participants’ to navigate the game’s environment within an abbreviated timeframe. A secondary purpose of the pretest was to ensure that the questionnaire presented to participants following game play would be easy to understand and answer. As a preemptive measure to eliminate any methodological problems with the study prior to data collection, the investigator chose 5% of the participants to experience the conditions of the study via pretesting. Therefore, three participants were asked to answer the pre-exposure questionnaire, undergo *Call of Duty: Modern Warfare 2* training, and complete the four stimulus conditions. The original goal was to pretest three participants and collect data from an additional 60 participants; however, data were only collected on 57 participants since the opportunity to participate in the study as closed at the end of the school term. The size of the

pretest was 5.2% of the sample population and excluded from the dataset used in the final analysis.

Pretesting was conducted by having participants complete the pre-exposure questionnaire, undergo *Call of Duty: Modern Warfare 2* training, and play the game with the four stimulus conditions presented in random order: high-paced, nonstereoscopic 2D; high-paced, stereoscopic 3D; low-paced, nonstereoscopic 2D; and low paced, stereoscopic 3D. Two lessons learned from the pretesting were applied during the study. A study protocol problem was revealed during participant training. During the training session, participants who selected the Xbox 360 controller were confused by the on-screen directions referring to the keyboard commands. The original intention was to provide each participant with a controller diagram that showed the participant which thumb sticks and buttons were used to perform in-game actions; however, the diagram was insufficient for training. To overcome this issue, participants were provided a separate sheet during training that identified keystrokes for the keyboard and labels for the actions that could be performed using the controller.

A second methodological issue was revealed with the obstacle course component of the pretest. It was intended that participants perform the obstacle course only once during the training session. However, the investigator noted that inexperienced users' performance was greatly improved after a second attempt at the obstacle course. A decision was made that each participant perform the obstacle course twice. This methodological decision bolstered the data in two ways. First, it provided an accurate baseline to determine whether participants should be placed into the high-GPC or low-GPC groups. This was important because, in some cases, the disparity between the performance in first and second trials was substantial and could have weakened the distinction between the low-GPC and high-GPC groups if the first score were

used. Second, since the experimental conditions were extremely short, it may have decreased some of the learning initial effects that could have occurred during the first round of the experimental conditions.

Procedure

Each individual participant scheduled an appointment to participate in the study. Two stations were prepared to collect data from two participants simultaneously. As participants arrived, they were greeted and invited into the media lab. Participants were seated in a chair and given an informed consent sheet. They were asked to read the form and several minutes were allotted to provide them with ample time to peruse it. Then, the process of the research project was explained to the participants. Participants were told that they would be asked to complete an initial questionnaire, then they would play a training session in a game titled *Call of Duty: Modern Warfare 2*. The participants were informed that for the remainder of the study they would be asked to play four, three-minute stimulus sessions with the game, *Call of Duty: Black Ops*, and to complete short questionnaires immediately following each of the sessions. The participants were asked not to interact with one another during the study. Once the procedures were explained, each participant was led to his or her research station. A divider separated each computer station in the study and headphones were used.

After a brief explanation of the project, an investigator handed the participants a study packet. The packet contained one pre-exposure questionnaire and four post-stimulus questionnaires. The pre-exposure questionnaire consisted of basic demographics, previous *Call of Duty: Black Ops* use, previous 3D movie-watching, and weekly game use items, and the visual spatial imagery scale. Each post-stimulus questionnaire included the spatial situation model, sense of self-location, perceived possible actions, and the cognitive involvement subscales. At

this point, participants were asked to complete their pre-exposure questionnaire. Once the pre-exposure questionnaire was completed, the investigator asked each participant what control mechanism he or she wanted to use: the Xbox 360 controller or the keyboard and mouse. After a participant selected a control device, the investigator prepared the training session.

Participants were asked to play through the *Call of Duty: Modern War 2* training chapter S.S.O.D., follow the in-game instructions, and ask the instructor for assistance with any training session problems. The S.S.O.D. chapter began by instructing the participant in the use of the in-game weapon within the confines of a firing range. After participants finished the firing range aspect of training, they were instructed by the game to proceed to “the pit” to run the obstacle course. In the event that a participant remained unfamiliar with the control scheme, the investigator verbally guided the participant toward the objective marker denoting the pit. The second portion of the training session required participants to navigate through a military-styled obstacle course while firing at human-shaped, wooden targets. The participants were informed that they were being timed and instructed to do their best to complete the training course by moving through it and shooting only “enemy” targets. The investigator recorded the time elapsed and the number of correct targets that had been hit by each participant navigating the obstacle course.

Participants were assigned to either a high or low game play competence group based on obstacle course performance. Once assigned to a competence group, a participant received a randomized code for the sequence of the four stimulus conditions and a competence group number. Both numbers were written on each participant’s study packet prior to the stimulus sessions. Randomized code numbers were generated using a separate randomization table for each competence group. After the investigator recorded the randomized code and group number,

the participant was informed that the study was commencing. The settings for the computer and one experimental condition were prepared based on the participant's randomized code.

Participants were asked to play through each of the following conditions in random order: high-paced, nonstereoscopic 2D; high-paced, stereoscopic 3D; low-paced, nonstereoscopic 2D; and low-paced, stereoscopic 3D. Each play session was three minutes. Participants then were asked to wait until the game appeared on the monitor before beginning play. Once the first experimental condition ended, participants completed the first post-stimulus questionnaire. Meanwhile, the investigator prepared the experimental condition identified by the randomized code. During this second play session, participants were allotted three minutes of game time. At the conclusion of this session, participants were asked to complete a second post-stimulus questionnaire. Meanwhile, the investigator prepared the third experimental condition identified by the randomized code. During this third play session, participants were allotted three minutes of game time. At the conclusion of this session, participants completed the third post-stimulus questionnaire. Meanwhile, the investigator prepared the fourth experimental condition identified by the randomized code. During this fourth session, participants were exposed to the final experimental condition for three minutes. At the conclusion of this session, participants completed the last post-stimulus questionnaire.

The procedure for each of the four experimental conditions was nearly identical with two exceptions: the randomized order of the treatments and the instructions for donning the 3D glasses necessitated by the stereoscopic 3D experimental conditions. The investigator turned on the 3D glasses and handed them to a participant with instructions for placing them on his or her face. Once participants complete the final post-exposure questionnaire items, the study packet was collected. The investigator thanked and debriefed each participant.

Analyses of Data

The *IBM SPSS Version 21.0 Grad Pack* (2012) was used as the statistical package in this project to perform data transformations, create indexes, and analyze study data.

Transformations and Indexes

Previous Call of Duty: Black Ops experience. A single item was used to measure the frequency with which a participant has played the game, *Call of Duty: Black Ops*. Participants were able to select a response from 0 - *Never* to 4 - *Frequent*. To compare the population characteristics of the two game play competence groups the mean of their raw scores was used. For some analysis, this item was transformed to nominal data with two outcomes. Responses 1, 2, 3, and 4 were coded as 0, 1, 2, and 3 respectively.

Previous 3D exposure. Prior 3D exposure has been used as one variable when investigating recent effects of stereo 3D exposure (see Obrist et al., 2011). In the current study, the number of times participants reported viewing 3D movies was collected and analyzed as ratio data. Those items provided information about the characteristic of two competence groups by comparing group means. A second measure of 3D experience was collected from a single *yes* or *no* response to the following question: Have you ever played a stereoscopic 3D game? This item was coded as a 0 for *no* and 1 for a *yes* response. It was used to describe each study group's characteristics.

Game play competence. The raw data used to determine the level of a participant's game play competence were collected and recorded by the investigator at the end of the training session. The raw data comprised the number of correct targets that the participant hit and the time elapsed to complete the obstacle course. Participants were asked to complete the obstacle course twice; best scores were used. To achieve placement in the high-GPC group, the

participant had to shoot all 24 targets while completing the obstacle course within 90 seconds, which translates to shooting one target per 3.75 seconds. Any participant who hit less than one target per every 3.75 seconds was assigned to the low-GPC group.

Visual spatial imagery. The visual spatial imagery scale was used to collect ordinal data on each participant's perceived ability to form a mental representation a depicted space (i.e., in this case, the virtual environment). This subscale contained four items to which participants had five possible responses: *1 - Strongly disagree, 2 - Disagree, 3 - Neutral, 4 - Agree, and 5 - Strongly agree.* Mean responses from the four-item subscale were calculated (see Vorderer et al., 2004) with the intention to analyze the findings; however, due a low Cronbach's alpha reliability (0.73) the subscale was not used.

Spatial situation model. The spatial situation model scale measures the strength of the mental representation of the depicted space. This subscale contained four items to which participants had five possible responses: *1 - Strongly disagree, 2 - Disagree, 3 - Neutral, 4 - Agree, and 5 - Strongly agree.* Mean responses from the four-item subscale were calculated (see Vorderer et al., 2004) and used for analysis. The Cronbach's alpha reliability for the scale was 0.83.

Sense of self-location. The sense of self-location scale measures the first dimension of spatial presence, that is, the psychological location within a virtual environment. This subscale contained four items to which participants had five possible responses: *1 - Strongly disagree, 2 - Disagree, 3 - Neutral, 4 - Agree, and 5 - Strongly agree.* Mean responses from the four-item subscale were calculated (see Vorderer et al., 2004) and used for analysis. The Cronbach's alpha reliability for the scale was 0.89.

Perceived possible actions. The perceived possible actions scale measures the second dimension of spatial presence, that is, the perception that one may act within an environment. This subscale contained four items to which participants had five possible responses: 1 - *Strongly disagree*, 2 - *Disagree*, 3 - *Neutral*, 4 - *Agree*, and 5 - *Strongly agree*. Mean responses from the four-item subscale were calculated (see Vorderer et al., 2004) and used for analysis. The Cronbach's alpha reliability for the scale was 0.80.

Cognitive involvement. Participants' perceived level of cognitive involvement was collected as ordinal data using a cognitive involvement subscale. This subscale contained four items to which participants had five possible responses: 1 - *Strongly disagree*, 2 - *Disagree*, 3 - *Neutral*, 4 - *Agree*, and 5 - *Strongly agree*. Mean responses from the four-item subscale were calculated (see Vorderer et al., 2004) with the intention to analyze the findings; however, due a low Cronbach's alpha reliability (0.71) the subscale was not used.

Missing Data

Pre-exposure to experimental conditions questionnaire. In several instances, participants did not complete a portion of the questionnaire that was administered prior to the experimental conditions. Three participants neglected to indicate the degree to which they had played *Call of Duty: Black Ops*. One participant failed to reveal his or her familiarity with stereoscopy in terms of 3D movies watched. Second trial obstacle course data were not collected for six participants.

Efforts were made to correct these issues. When no indication was provided for participants' previous use of *Call of Duty: Black Ops*, the sample mean was entered into the three observations that contained missing data. For the single participant who did not indicate the number of 3D movies watched, the sample mean was used. In the case of the six participants

with missing second trail obstacle course scores, scores from their first trials, including number of targets hit and elapsed time, were recorded as their second trial score.

Experimental condition questionnaire. There were missing data from the experimental conditions as well. These issues were addressed. Only 12 responses were missing from the entire number of subscale items pertaining to the experimental conditions. One missing response was identified for a subscale item in the low-paced, nonstereoscopic 2D condition; nine missing responses were identified for subscale items in the high-paced, nonstereoscopic 2D condition; two missing responses were identified for subscale items in the high-paced, stereo 3D condition. To account for missing data within an experimental condition, the mean from the three other items the participant answered associated with that particular subscale were used as the observation for the missing data.

Testing of Hypotheses

The first hypothesis posits that participants will form stronger SSMs when exposed to stereo 3D stimuli than when exposed to nonstereoscopic 2D stimuli. To address this hypothesis, both high-GPC and low-GPC sample groups were analyzed as a single group. A repeated measures ANOVA was performed on SSM scores for nonstereoscopic 2D and stereo 3D exposure and low pacing and high pacing levels. When significant differences were found, a Bonferroni multiple comparisons procedure was performed on two pairs. The first comparison was made between the scores of the low-paced, nonstereoscopic 2D and the low-paced, stereo 3D conditions; the second comparison was made between the scores of the high-paced, nonstereoscopic 2D and the high-paced, stereo 3D conditions.

The second hypothesis states that participants will experience greater spatial presence as sense of self-location and perceived possible actions when exposed to stereo 3D stimuli. To

address this hypothesis, both high-GPC and low-GPC sample groups were analyzed as a single group. Repeated measures ANOVAs were performed separately with the dependent variables sense of self-location and perceived possible actions analyzed as within-subjects factors for nonstereoscopic 2D and stereo 3D exposure and low pacing and high pacing levels. When significant differences were found, a Bonferroni multiple comparisons procedure was performed on the two pairs in each ANOVA. To examine the effects of stereo 3D conditions on sense of self-location and perceived possible actions, two comparisons were performed for each dependent variable. The scores from the low-paced, nonstereoscopic 2D were compared to those from the low-paced, stereo 3D condition; and the scores from the high-paced, nonstereoscopic 2D were compared to the scores of the high-paced, stereo 3D condition.

The third hypothesis posits that participants with high game play competence will form more robust spatial situation models, experience greater sense of self-location, and an increase in perceived possible actions than participants with low game play competence. Repeated measures ANOVAs were performed on the three separate dependent variables of SSM, sense of self-location, and perceived possible actions with nonstereoscopic 2D and stereo 3D stimuli exposure and low pacing and high pacing levels as within-subjects factors and game play competence as the between-subjects factor.

Hypothesis 4 assumes that participants with high game play competence will construct stronger SSMs when exposed to stereo 3D stimuli than when exposed to nonstereoscopic 2D stimuli. A repeated measures ANOVA was performed on the high-GPC group scores with nonstereoscopic 2D and stereo 3D stimuli exposure and low pacing and high pacing levels as the within-subjects factors for each sample group. When significant differences were found, a Bonferroni multiple comparisons procedure was performed on the two pairs to examine the

effects of stereo 3D exposure. The scores of the low-paced, nonstereoscopic 2D condition were compared to the scores of the low-paced, stereo 3D condition, and the scores of the high-paced, nonstereoscopic 2D condition were compared to scores of the high-paced, stereo 3D condition.

Hypothesis 5 suggests that participants with high game play competence will experience greater sense of self-location when exposed to the stimuli in stereo 3D than when exposed to nonstereoscopic 2D stimuli. Repeated measures ANOVAs were performed, including two repeated measures ANOVAs using nonstereoscopic 2D and stereo 3D stimuli exposure and low pacing and high pacing levels as within-subjects factors on high-GPC and low-GPC groups. When significant differences were found, a Bonferroni multiple comparisons procedure was performed on the two pairs to examine the effects of stereo 3D exposure. The scores of the low-paced, nonstereoscopic 2D condition was compared to the scores of the low-paced, stereo 3D condition, and the scores of the high-paced, nonstereoscopic 2D condition were compared to scores of the high-paced, stereo 3D condition.

Hypothesis 6 posits that participants with high game play competence will experience an increase in perceived possible actions when exposed to the stimuli in stereo 3D than when exposed to nonstereoscopic 2D stimuli. A repeated measures ANOVA was performed using nonstereoscopic 2D and stereo 3D stimuli exposure and low pacing and high pacing levels as within-subjects factors. The perceived possible actions scores for the four experimental conditions were used as the dependent variables for their respective groups. When significant differences were found, Bonferroni multiple comparisons were performed on the two pairs to examine the effects of the stereo 3D condition. The scores of the low-paced, nonstereoscopic 2D condition were compared to the scores of the low-paced, stereo 3D condition, and the scores of

the high-paced, nonstereoscopic 2D condition were compared to scores of the high-paced, stereo 3D condition.

Hypothesis 7 assumes an interaction between stereoscopy, pacing levels, and game play competence on three dependent variables: SSM strength, sense of self-location, and perceived possible actions. High-GPC participants playing a high-paced, stereo 3D video game will (a) form stronger SSMs, (b) experience greater sense of self-location, and (c) perceive more possible actions compared to high-GPC participants playing within the parameters of the three other experimental conditions. Low-GPC participants playing a low-paced, stereo 3D action video game will (a) form stronger SSMs, (b) experience greater sense of self-location, and (c) perceived more possible actions compared to low-GPC participants playing within the parameters of the three other experimental conditions. Both high-GPC and low-GPC samples were combined in these analyses. Three repeated measures ANOVAs were performed. Nonstereoscopic and stereoscopic stimuli exposure and low pacing and high pacing levels were used as within-subjects factors, and game play competence was used as the between-subjects factor. The SSM scores, sense of self-location scores and perceived possible actions scores were used for the three ANOVAs.

CHAPTER IV

Results

Demographics

Data were collected from 57 participants. The proportion of male to female participants in the overall study was relatively balanced: 56% were male and 44% were female; however, the GPC groups were unbalanced relative to gender. Most participants were Caucasian (74%); 15% were African American; 7% were Hispanic; 4% were Asian or Pacific islanders. Participants' self-reported time spent each week playing video games revealed that 42% did not play video games, 30% played 1 to 3 hours a week, 28% played 3 to 9 hours a week, and 7% played more than 10 hours per week.

Participants were assigned to either a high-GPC or a low-GPC group based on measured assessments of their respective in-game performance. Twenty-nine participants were placed into the low-GPC group, and 28 participants were placed into the high-GPC group. The composition of the low-GPC group by gender was 83% female and 17% male. The low-GPC group reported using video games less during the week than did the high-GPC group, $F(1, 56) = 12.490, p < .001$; 62% of the low-GPC group reported not playing video games at all, 24% reported playing one to three hours, and 14% reported playing four to 10 hours weekly. Within the high-GPC group, 96% of the participants were male and 4% were female: 21% reported not playing games, 36% reported playing one to three hours, 29% reported played four to 10 hours, and 14% reported played more than 10 hours per week.

There was a significant difference between the two groups with regard to participants' previous exposure to *Call of Duty: Black Ops*, the action video game used as in the experimental conditions. The low-GPC group had significantly less exposure than did the high-GPC group to *Call of Duty: Black Ops*, $F(1, 55) = 45.542, p < .001$. However, there was no significant difference between the two GPC groups prior to stereo 3D stimuli exposure relative to the number of stereo 3D movies watched, $F(1, 55) = .000, p = .983$, or stereo 3D games played, $F(1, 56) = .252, p = .618$.

There was a significant difference between the high- and low-GPC groups; $F(1, 56) = 63.458, p < .001$, and $F(1, 56) = 27.096, p < .001$, respectively for the time elapsed during the obstacle course and the number of targets hit. The low-GPC group spent more time (in seconds) to complete the obstacle course ($M = 103.69, SD = 20.88$) and hit fewer targets ($M = 16.29, SD = 5.11$) than did the high-GPC group, which required less time (in seconds) to complete the obstacle course ($M = 66.66, SD = 13.22$) and hit more targets ($M = 23.5, SD = 5.30$).

Data Analyses

Seven research hypotheses were formulated to predict several research outcomes. Hypothesis 1 states that participants will form stronger spatial situation models (SSMs) when exposed to stereo 3D stimuli than when exposed to 2D stimuli. To examine the first hypothesis, the high-GPC and low-GPC groups were analyzed as a single group using a repeated measures ANOVA with stereo 3D and pacing as within-subjects factors. There was a significant effect of stereo 3D exposure on the spatial situation model, $F(1, 56) = 16.14, p < 0.001, r^2 = 0.224$. Test of two *a priori* comparisons were performed using Bonferroni's adjusted alpha levels of 0.0125 (0.05/4). A Bonferroni multiple comparisons procedure compared (a) the low-paced, nonstereoscopic condition ($M = 3.50, SD = 0.74$) to the low-paced, stereoscopic condition ($M =$

3.89, $SD = 0.65$); and (b) the high-paced, nonstereoscopic condition ($M = 3.54$, $SD = 0.75$) to the high-paced, stereoscopic condition ($M = 3.84$, $SD = 0.65$) for SSM strength. Both comparisons were significant: Within the low-paced and high-paced game play segments, stereo 3D exposure led to stronger SSMs than did 2D exposure. Participants' exposure to stereo 3D stimuli contributed to a significant increase in their SSMs when pacing is low or high. The first hypothesis is confirmed and the finding suggests that stereo 3D exposure likely facilitates the formation of more robust SSMs for a varied population.

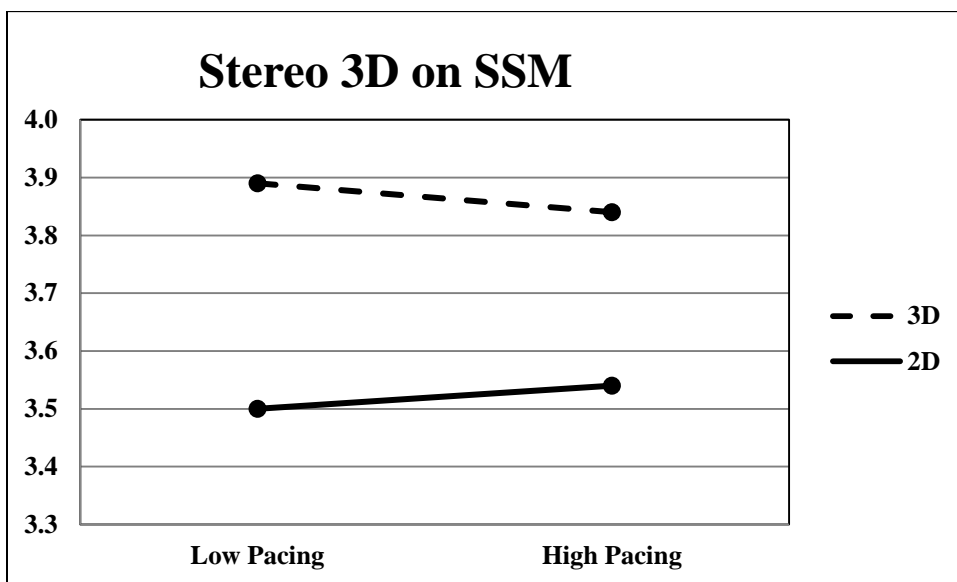


Figure 1. Hypothesis 1: Stereo 3D on SSM.

Note. Scale ranges from 3.3 to 4.0.

Hypothesis 2 speculates that exposure to stereoscopic 3D stimuli will lead to greater spatial presence operationalized as a sense of self-location and perceived possible actions. The two dimensions of this hypothesis were analyzed separately. High-GPC and low-GPC groups were examined as a single group; two repeated measures ANOVAs were performed with stereo 3D and pacing as within-subjects factors to examine both dimensions. Exposure to stereo 3D stimuli produced a significant effect on the sense of self-location, $F(1, 56) = 39.58$, $p < 0.001$, r^2

= 0.414. Two a priori comparisons were performed using Bonferroni's adjusted alpha levels of 0.0125 (0.05/4). The Bonferroni multiple comparison procedure compared (a) the low-paced, nonstereoscopic condition ($M = 3.07, SD = 0.89$) to the low-paced, stereoscopic condition ($M = 3.69, SD = 0.89$), and (b) the high-paced, nonstereoscopic condition ($M = 3.10, SD = 0.80$) to the high-paced, stereoscopic condition ($M = 3.83, SD = 0.78$) for sense of self-location. Each Bonferroni comparison was significant, suggesting that stereo 3D stimuli exposure leads to greater spatial presence for the sense of self-location dimension than does nonstereoscopic stimuli exposure. The first part of hypothesis 2 is supported by the findings.

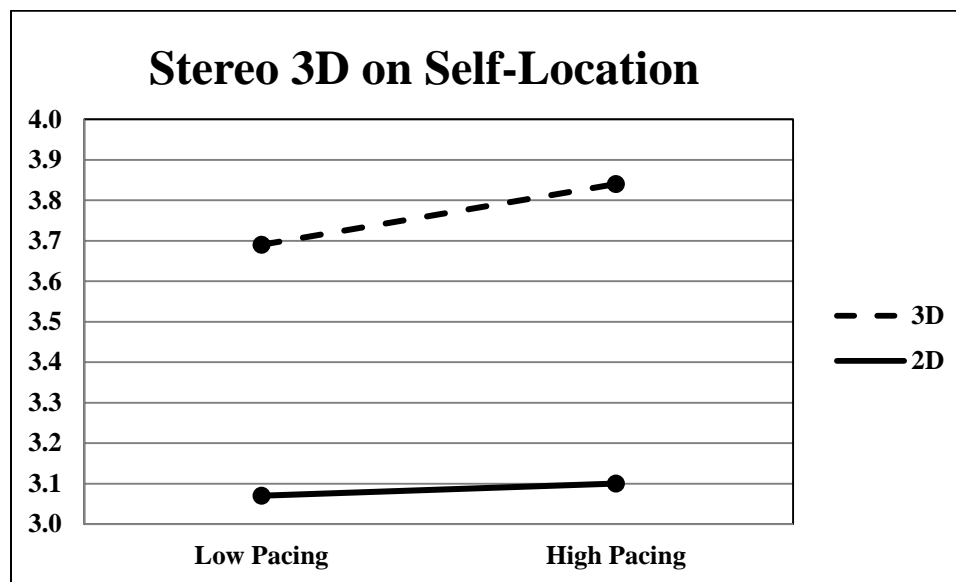


Figure 2. Hypothesis 2: Stereo 3D on sense of self-location dimension.

Note. Scale ranges from 3.0 to 4.0.

The repeated measures ANOVA produced significant effects for stereo 3D stimuli exposure on the second dimension of spatial presence: participants' perceived possible actions, $F(1, 56) = 18.15, p < 0.001, r^2 = 0.245$. Two a priori comparisons were performed using Bonferroni's adjusted alpha levels of 0.025 (0.05/2). A Bonferroni multiple comparisons procedure compared (a) the low-paced, nonstereoscopic condition ($M = 3.44, SD = 0.75$) to the

low-paced, stereoscopic condition ($M = 3.71$, $SD = 0.68$) and (b) the high-paced, nonstereoscopic condition ($M = 3.35$, $SD = 0.69$) to the high-paced, stereoscopic condition ($M = 3.75$, $SD = 0.70$) for perceived possible actions. Stereoscopic 3D stimuli exposure indicated significantly higher reports of perceived possible actions leading to greater spatial presence in both the low-paced and high-paced conditions. These results affirm the supposition that exposure to stereoscopic 3D stimuli will lead to greater spatial presence through participants' perceived possible actions than nonstereoscopic stimuli exposure does.

Hypothesis 1 assumed that stereo 3D stimuli exposure facilitates the construction of SSMs. As stated in Chapter 1, a robust SSM indirectly increases the likelihood of accepting the game-as-PERF perceptual hypothesis and stereo 3D stimuli exposure increases the likelihood of accepting the game-as-PERF hypothesis. The expressed confirmation of hypothesis 2 supports the likelihood that a varied population experienced spatial presence as the sense of self-location and perceived possible actions.

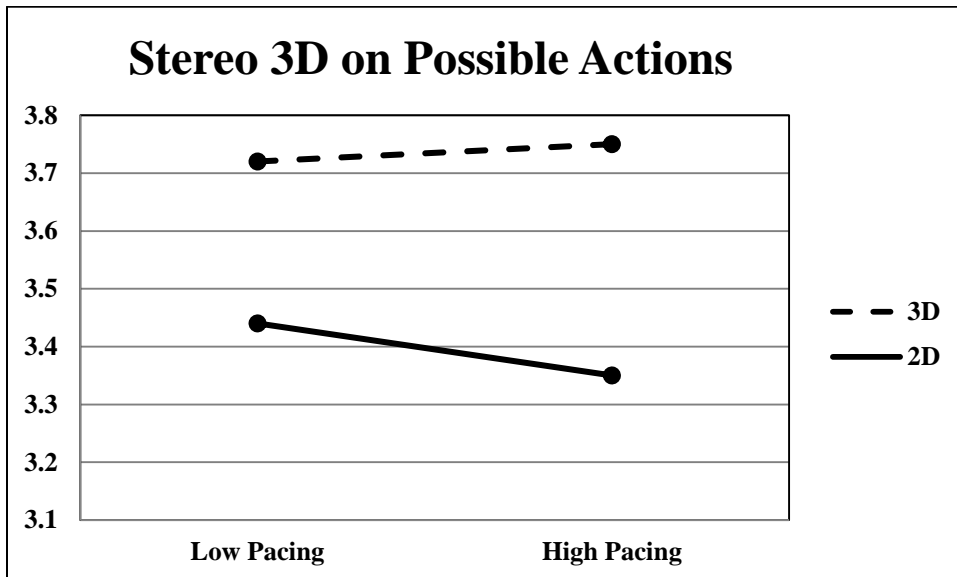


Figure 3. Hypothesis 2: Stereo 3D on perceived possible actions dimension.

Note. Visible scale ranges from 3.1 to 3.8.

The three-part third hypothesis assumes that high game play competence forms (a) a more robust spatial situation model, (b) greater sense of self-location, and (c) an increase in perceived possible actions. Repeated measures ANOVAs were performed with stereo 3D and pacing as within-subjects factors and game play competence as the between-subjects factor on participants' scores for three separate dependent variables: the spatial situation model, sense of self-location, and perceived possible actions. Game play competence was not a significant factor for the formation of a spatial situation model, $F(1, 55) = 3.238, p = 0.13, r^2 = 0.041$; experiencing self-location, $F(1, 55) = 1.140, p = 0.29, r^2 = 0.02$; or perceived possible actions, $F(1, 55) = 0.15, p = 0.090, r^2 = 0.00$. Therefore, all three propositions of the third hypothesis (i.e., 3a, 3b, and 3c) were rejected. The rejection of hypothesis 3 in its entirety suggests that there is no significant difference between the high-GPC group and low-GPC group regarding the formation of a spatial situation model, sense of self-location, and perceived possible actions. These findings indicate that high game play competence does not independently contribute to the formation of participants' spatial situation model or the experience of self-location and perceived possible actions.

Hypothesis 4 theorizes that high-GPC participants will construct stronger SSMs when exposed to stereoscopic 3D stimuli than when exposed to 2D stimuli. Repeated measures ANOVAs were performed using high-GPC group scores with stereo 3D and pacing as within-subjects factors. A Bonferroni multiple comparisons procedure compared (a) the low-paced, stereoscopic condition to the low-paced, nonstereoscopic condition and (b) the high-paced, stereoscopic condition to the high-paced, nonstereoscopic condition. Within the high-GPC group, there was a significant effect of stereo 3D exposure on the spatial situation model, $F(1, 27) = 14.676, p < .001, r^2 = 0.352$. The two *a priori* comparisons on the high-GPC groups were

performed using Bonferroni’s adjusted alpha levels of 0.025 (0.05/2). There was a significant difference between the low-paced, stereoscopic condition ($M = 4.08, SD = 0.63$) and the low-paced, nonstereoscopic condition ($M = 3.49, SD = 0.67$) and between the high-paced, stereoscopic condition ($M = 4.03, SD = 0.62$) and the high-paced, nonstereoscopic condition ($M = 3.61, SD = 0.77$) for SSM strength.

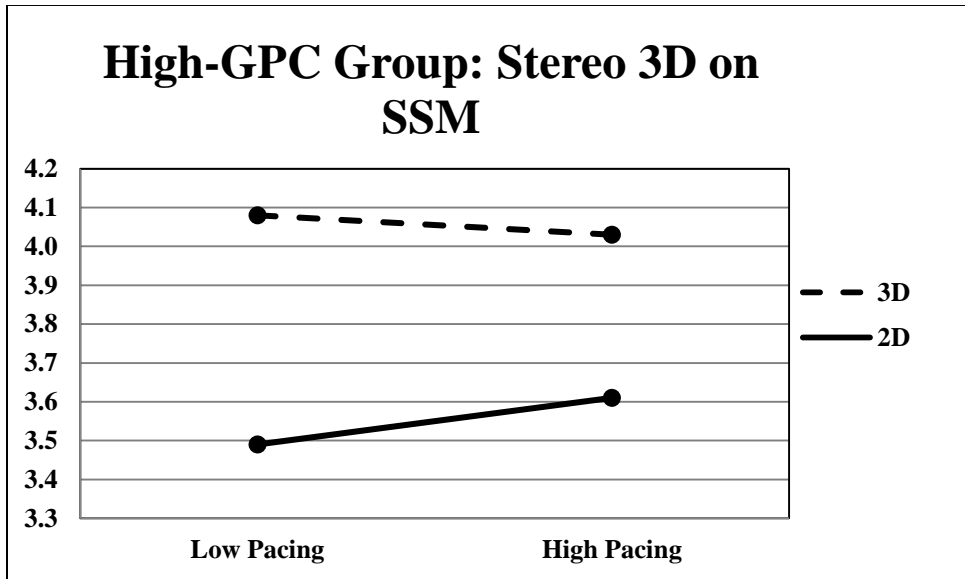


Figure 4. Hypothesis 4: High-GPC group: Stereo 3D on SSM.

Note. Scale ranges from 3.3 to 4.2.

The effects of stereo 3D exposure on SSM strength were analyzed for the low-GPC group. Repeated measures ANOVAs were performed using low-GPC group scores with stereo 3D and pacing as within-subjects factors. Findings reveal that exposure to stereoscopic 3D stimuli did not significantly affect participants’ SSM strength, $F(1, 28) = 3.272, p = .081, r^2 = .105$. These findings suggest that among individuals with high game play competence, playing in stereo 3D, may facilitate the building of stronger SSMs, but not for those individuals with fewer game-playing skills. These findings coincide with the assertion that individuals who have high

game play competence may be able to use their allocable resources to construct more robust SSMs.

Hypothesis 5 proposes that high-GPC participants will exhibit a greater increase in the sense of self-location with stereoscopic 3D stimuli exposure than with 2D stimuli exposure. A repeated measures ANOVA was performed using high-GPC group scores with stereo 3D and pacing as the within-subjects factors. There was a significant effect of stereo 3D exposure on participants' sense of self-location, $F(1, 27) = 54.267, p < 0.001, r^2 = 0.668$. Two *a priori* comparisons were performed using Bonferroni's adjusted alpha levels of 0.025 (0.05/2). A Bonferroni multiple comparisons procedure compared (a) the low-paced, stereoscopic condition ($M = 3.78, SD = 0.97$) to the low-paced, nonstereoscopic condition ($M = 2.68, SD = 0.75$); and (b) the high-paced, stereoscopic condition ($M = 4.00, SD = 0.79$) to the high-paced, nonstereoscopic condition ($M = 2.86, SD = 0.73$) for the sense of self-location dimension. These findings represent a significant difference between stereo 3D and nonstereoscopic exposures for low pacing and a significant difference between stereo 3D and nonstereoscopic exposures for high pacing among participants of the high-GPC group on this dimension. Hypothesis 5 is supported.

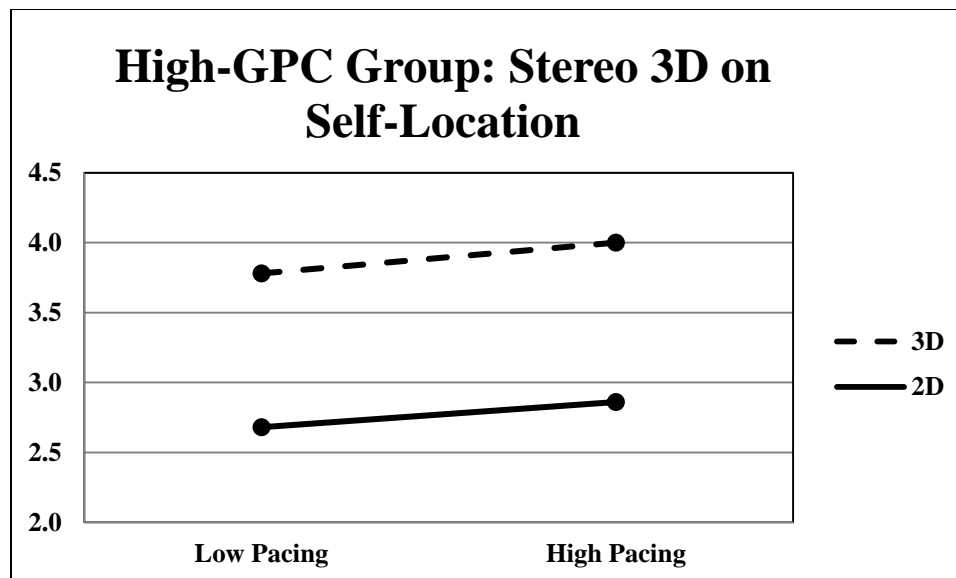


Figure 5. Hypothesis 5: High-GPC group: Stereo 3D on sense of self-location dimension.

Note. Visible scale ranges from 2.0 to 4.5.

A repeated measures ANOVA was performed using low-GPC group scores with stereo 3D and pacing as within-subjects factors to examine their effects on sense of self-location. Stereo 3D stimuli exposure significantly affected the strength of participants' sense of self-location, $F(1, 27) = 5.733, p < 0.024, r^2 = 0.170$, in the low-GPC group. Posteriori comparisons were performed for two conditions using Bonferroni's adjusted alpha levels of 0.025 (0.05/2). There was no significant difference for sense of self-location experienced between the low-paced, stereoscopic condition ($M = 3.61, SD = 0.82$) and the low-paced, nonstereoscopic condition ($M = 3.44, SD = 0.87$). However, the sense of self-location experienced for the high-paced, stereoscopic condition ($M = 3.68, SD = 0.76$) was greater than that experienced for the high-paced, nonstereoscopic condition ($M = 3.32, SD = 0.80$) in the low-GPC group. It was expected that game-playing in stereo 3D among participants with high game play competence would assist them with constructing stronger SSMs and likely increase their experiencing of spatial presence. It was not expected that exposure to stereo 3D stimuli by those participants with fewer game-

playing skills (i.e., low-GPC group) would lead to a sense of self-location, especially since there was no significant increase in the group’s SSM with stereo 3D stimuli exposure.

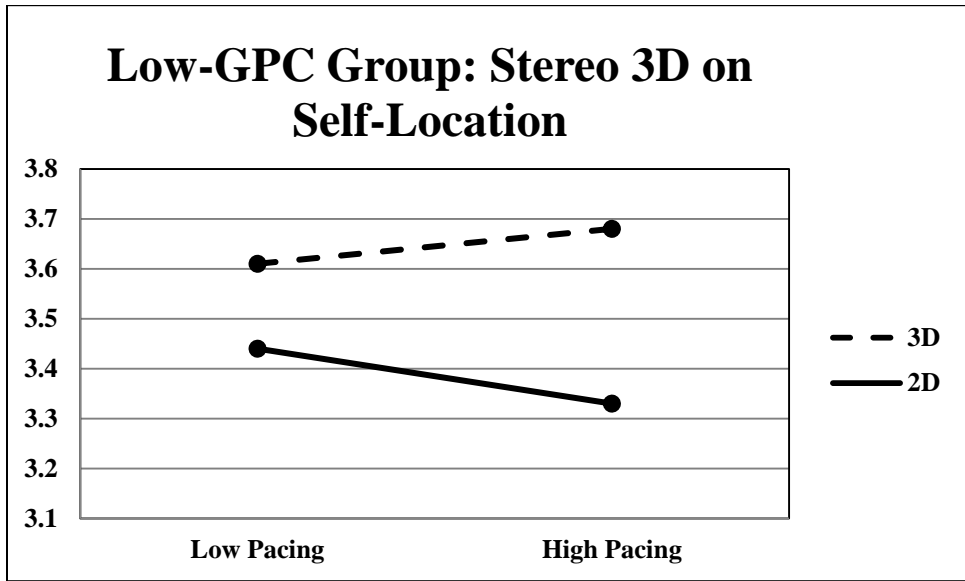


Figure 6. Hypothesis 5: Low-GPC group: Stereo 3D on sense of self-location dimension.

Note. Visible scale ranges from 3.1 to 3.8.

Hypothesis 6 posits that the high-GPC group will perceive more possible actions when exposed to stereoscopic 3D stimuli than when exposed to 2D or nonstereoscopic stimuli. A repeated measures ANOVA was performed using high-GPC group scores with stereo 3D and pacing as within-subjects factors. A significant effect of stereo 3D was determined for perceived possible actions for the high-GPC group, $F(1, 27) = 24.672, p < 0.001, r^2 = 0.477$. Two *a priori* comparisons were performed using Bonferroni’s adjusted alpha levels of 0.0125 (0.05/4). A Bonferroni multiple comparisons procedure compared (a) the low-paced, stereoscopic condition ($M = 3.77, SD = 0.73$) to the low-paced, nonstereoscopic condition ($M = 3.26, SD = 0.69$); and (b) the high-paced, stereoscopic condition ($M = 3.95, SD = 0.73$) to the high-paced, nonstereoscopic condition ($M = 3.24, SD = 0.69$) for the perceived possible actions dimension. Significant differences also exist between the low-paced, stereoscopic condition and the low-

paced, nonstereoscopic condition for perceived possible actions by participants in the high-GPC group. Significant differences exist between the high-paced, stereoscopic condition and the high-paced, nonstereoscopic condition for perceived possible actions by high-GPC group participants. Participants with high game play competence perceive more possible actions during game play in both low- and high-paced conditions when exposed to 3D stimuli than when exposed to nonstereoscopic stimuli under either condition (i.e., low or high pacing). Hypothesis 6 is supported.

A repeated measures ANOVAs was performed using low-GPC group scores to determine the effects of stereo 3D on perceived possible actions with stereo 3D and pacing as within-subjects factors. Stereo 3D stimuli exposure did not reveal significant differences in the perceived possible actions within the game environment for the low-GPC group, $F(1, 28) = 1.086, p = .306, r^2 = .037$. As stated previously, perceived possible actions that become bound to the media instead of reality represent the second dimension of spatial presence. Perceived possible actions are more likely to occur because more of the user's cognitive resources are available to form a robust SSM and to process content. The mere presence of a robust SSM facilitates experiencing dimensions of spatial presence.

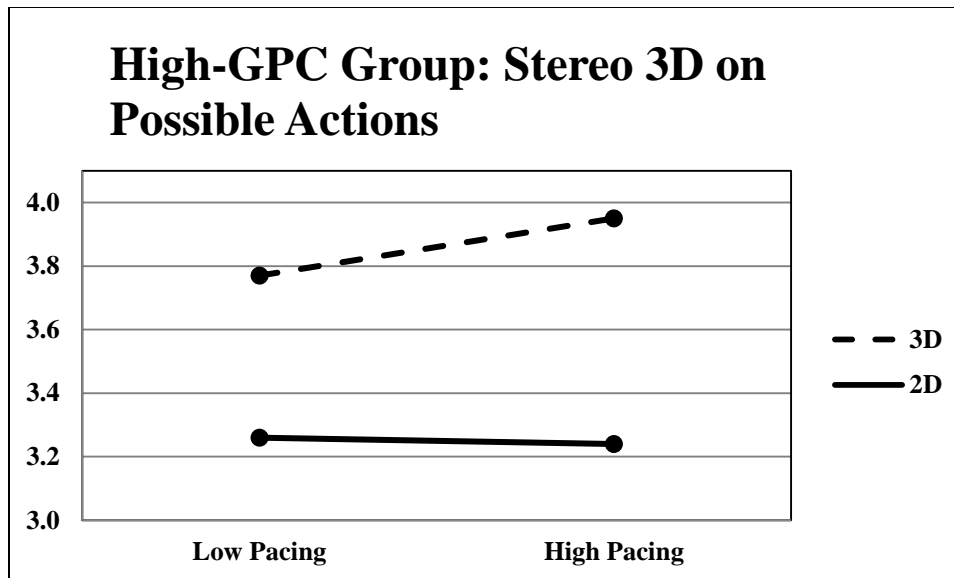


Figure 7. Hypothesis 6: High-GPC group: Stereo 3D on perceived possible actions dimension.

Note. Visible scale ranged from 3.0 to 4.0.

The seventh hypothesis posits that there will be an interaction between stereo 3D, pacing and game play competence on the strength of the spatial situation model, experiencing self-location, and possible actions. It is expected that when high-GPC participants play in the high-paced, 3D condition they will (a) form stronger SSMs, (b) experience greater sense of self-location, and (c) perceive more possible actions than when they play in the other experimental conditions. It is also expected that when low-GPC participants play in the low-paced, 3D conditions they will (a) form stronger SSMs, (b) experience greater sense of self-location, and (c) perceived more possible actions than when they play in the other experimental conditions.

To address hypothesis 7, three repeated measures ANOVAs were performed with stereoscopy (stereo 3D vs. 2D) and levels of pacing (low and high) as the within-subjects factors and game play competence as the between-subject factor. There were no significant interaction effects for hypothesis 7a, $F(1, 55) = 0.400, p = 0.530, r^2 = .007$; hypothesis 7b, $F(1, 55) = 0.347, p = 0.558, r^2 = .006$; or hypothesis 7c, $F(1, 55) = 0.358, p = 0.552, r^2 = .006$. Therefore, hypotheses 7a, 7b, and 7c are not supported.

Additional Analyses

Since the GPC groups were skewed by gender, three additional *a posteriori* analyses were performed to control for gender effects. Repeated measures ANOVAs (2x2x2) were performed with stereo 3D exposure and pacing as the within-subject factors; game play competence as the between-subjects factor and gender as a covariate for SSM strength, sense of self-location, and perceived possible actions. When controlling for gender, stereo 3D nonetheless revealed significant effects for spatial situation model strength, $F(1, 54) = 8.657, p = .005, r^2 = 13.8$, and sense of self-location, $F(1, 54) = 12.151, p < .001, r^2 = 18.4$; however, stereo 3D exposure did not significantly affect perceived possible actions. Two pairs of Bonferroni multiple comparisons similar to those used for hypotheses 4, 5 and 6 were performed to ascertain the effects of stereo 3D stimuli exposure on the SSM and self-location scores when controlling for gender. Low-paced, 2D stimuli exposure was compared to low-paced, stereo 3D stimuli exposure and high-paced, 2D stimuli exposure was compared to high-paced, stereo 3D stimuli exposure. Stereo 3D stimuli exposure did not lead to the formation of stronger SSMs in the high-paced or low-paced conditions; however, stereo 3D did lead to the experience of self-location. Unfortunately, the gender variable confounds some of the findings of this experiment because the high-GPC group included only one female, and the low-GPC group contained only five males.

CHAPTER V

Conclusions and Discussion

This chapter summarizes the literature review, methods, and results of this study in the second, third, and fourth chapters, respectively. The key findings of this research are discussed relative to the spatial presence model and the LC4MP. Then, the findings are discussed within the broader context of the related literature by addressing alternative explanations for this study's findings as well as the external validity of the experiment. The limitations of this research also are addressed. Future directions of analogous research are presented.

Summary

Video games, which are popular worldwide, are becoming increasingly realistic as advancing technology has led to greater sound fidelity and higher resolution imagery with 3D stereoscopic graphics. The wide variety of displays on which these games are played include stereoscopic 3D displays, which are widely available. Often, 3D capabilities are standard features on the newer televisions.

Research suggests that users playing in stereo 3D experience greater sustained arousal, the sensations of presence, spatial presence, and increased enjoyment (Ellis et al., 2011; Rajae-Joordens, 2008; Shafer et al., 2011; Takatalo et al., 2011). According to the spatial presence model, stereo 3D stimuli enhance spatial presence in several ways. Stereo 3D may increase the user's attention and provide helpful spatial information to assist with his or her construction of a SSM, which represents the user's personal spatial representation of the virtual environment (Schild et al., 2012; Wirth et al., 2007). Stereo 3D strengthens the user's acceptance of the game-

as-PERF hypothesis, which leads to sense of self-location and perceived possible actions within the world of the game.

Action video games of the first-person shooter variety are one of the more popular genres of video gaming. The scenarios within games of this genre offer varying degrees or levels of pacing. In this study, pacing is defined as the number of virtual threats within a scenario with which users can interact during a specific period. Action video games, such as shooter games, not only require a variety of skills, but each skill must be performed efficaciously. The attainment of each skill and the level to which each is performed is different for each user. Shooter games require users to (a) process fast-moving visual content, (b) understand the controls for initiating actions, and (c) use those actions within game content context (Feng, et al., 2007; Green & Bavelier, 2006b; Lindley & Sennersten, 2008).

Video game users develop greater visual cognitive efficiencies and game-related skillsets that enable them to process the content of and perform within a video game (Green & Bavelier, 2006a; Green & Bavelier, 2006b; Green & Bavelier, 2007). Users' high game play competence is indicative of their capability to perform successfully the required tasks of the game; however, users with low game play competence do not have all the requisite capabilities to perform the required tasks of the game. According to LC4MP, if cognitive capacity is inadequate, then users may not have insufficient, allocable resources to process the game's content in its entirety (Lang, 2005). Additionally, Lee and Kim (2008) suggest that some amount of cognitive overhead is essential if a user is to experience spatial presence. It is suggested that stereo 3D graphics contribute to the experience of spatial presence; yet, few investigations have examined the combined effects of stereo 3D, pacing, and user skills (i.e., high or low game play competence) on the processes of the spatial presence model.

Some users may think that their video gaming abilities and proficiencies are low because they have difficulty understanding and navigating the virtual surroundings that comprise the game's content. Although stereo 3D can assist some users, those with lesser skills may be unable to perform the required tasks for successful game playing. That could decrease users' enjoyment, deterring them from playing video games *in toto*, certain genres, or specific games. When researchers understand how stereo 3D graphical imagery and pacing can be implemented to create positive effects for low-GPC users, developers can design games that facilitate users' orientation to virtual environments, which can lead to less-skilled users' greater enjoyment of game playing.

This study's experiment was designed to examine the effects of 3D stereoscopy, pacing, and game-playing skill on the processes within the spatial presence model. A mixed 2 (Stereo 3D vs. 2D [within]) x 2 (high-paced vs. low-paced [within]) x 2 (high-GPC vs. low-GPC [between]) study was designed. Fifty-seven participants were recruited. Each participant was assigned to a high or low game-playing skills group based upon an in-game performance score, which was determined by the number of enemy targets a participant hit while navigating an obstacle course.

All participants underwent training prior to the application of the experimental conditions. *Call of Duty: Modern Warfare 2*, the *Call of Duty* franchise game released in 2009, was used for training and participant evaluation. Training consisted of shooting standard targets from various distances, learning to throw a grenade at targets, switching weapons, and navigating the spatial environment. Once training was complete, each user's obstacle course performance was scored and evaluated using the number of enemy targets hit and the time elapsed to navigate the environment. Participants were assigned to the high-GPC or the low-GPC group based upon

their respective obstacle course performance. Within-group randomization was conducted to diminish ordering and learning effects.

Basic demographics information was collected from the participants using a pre-exposure questionnaire (see Appendix A). Participants played the game *Call of Duty: Black Ops* (2010) for the experimental conditions. Specialized stereo 3D monitors and 3D software were used to render the game in stereo 3D. Each participant had the option of playing using either an Xbox 360 controller or a keyboard and mouse. Each participant was exposed to each of the four experimental conditions: low-paced, 2D; low-paced, 3D; high-paced, 2D, and high-paced, 3D. Between each condition, participants were asked to complete a short questionnaire comprised of several MEC-SPQ questionnaire items. The post-questionnaire items included four MEC-SPQ subscales to measure participants' SSM strength, sense of self-location, perceived possible actions, and cognitive involvement.

Several findings were suggested by the results. First, for the sample as a single group, 3D game use led to stronger SSMs and greater experiences of sense of self-location and perceived possible actions. Second, high game play competence did not independently lead to stronger SSMs and experiences of greater sense of self-location and perceived possible actions. Third, high-GPC participants formed stronger SSMs, experienced a greater sense of self-location, and perceived possible actions when playing the game in stereo 3D. Fourth, low-GPC participants did *not* form stronger SSMs or experience greater perceived possible actions when playing the game in stereo 3D; however, they did experience a greater sense of self-location when the game was high-paced.

Findings

How participants formed SSMs and the relationship of SSMs to the experiences of sense of self-location and perceived possible actions are discussed. The implications of the actual findings as they relate to the spatial presence model and LC4MP are presented.

SSMs are an integral part of experiencing spatial presence and without them users require greater amount of confirmatory information to experience spatial presence. In some cases in this study SSM, sense of self-location, and perceived possible actions increased significantly when stereo 3D was present, which may suggest that that the model worked as intended since a stronger SSM likely contributed directly to later processes within the model. If the SSM, sense of self-location, and perceived possible actions were not significant, then that would indicate a weaker SSM, decreased the likelihood experiencing spatial presence. In this study, a specific case was discovered in which stereo 3D did not significantly increase SSM strength, but did significantly increase sense of self-location. Under this circumstance, the SSM most likely did not lead to a robust ERF or game-as-PERF hypothesis, but the qualities of the stereo 3D stimuli likely presented users with adequate perceptual evidence to accept the game-as-PERF hypothesis.

Hypotheses 1 and 2 examined the sample as a single group of users composed of heterogeneous individuals with varying levels of shooter game-related skills. Within this broad range of users, stereo 3D exposure resulted in stronger SSMs and a greater sense of self-location and perceived possible actions, which suggest that spatial presence was likely experienced. Stereo 3D exposure yielded a moderately sized effect ($r^2 = .22$) on participants' SSMs, suggesting that 3D provided visual depth information useful for creating stronger SSMs. Within Wirth et al.'s (2007) spatial presence model, spatial presence is experienced as the dimensions of sense of self-location in an environment and, sometimes, as the perceived possible actions within

the context of a game's content. Exposure to stereo 3D conditions had a relatively strong effect on the sense of self-location ($r^2 = .41$) and a moderate effect on perceived possible actions ($r^2 = .25$). Since stereo 3D led to more robust SSMs, stronger ERFs and robust game-as-PERF hypotheses also were more likely to form because of the stronger SSMs. Since each of the dimensions of spatial presence were significantly affected by stereo 3D, it also is likely that stereo 3D provided greater confirmatory evidence for the game-as-PERF hypothesis. Within this scenario, it is likely that stereo 3D led participants to experience spatial presence or have a greater propensity to experience spatial presence.

When GPC was high, it was posited that participants had more cognitive resources available to dedicate to the encoding, storage, and retrieval sub-processes while playing the game. Interestingly, high-GPC did not necessarily lead to the formation of stronger SSMs or a greater sense of self-location or perceived possible actions. Regardless of the study condition, individuals with a greater skillset should have more allocable cognitive resources than should individuals with lesser skills. This finding suggests that game-related skill alone is not an adequate factor to explain the increased strength of the SSM and experiences of sense of self-location and perceived possible actions.

While exposed to the experimental conditions, high-GPC participants should have had more allocable cognitive resources than low-GPC participants should for encoding, storage and retrieval sub-processes related to game play. Hypotheses 4, 5, and 6 examined the effects of stereo 3D exposure on the SSM, sense of self-location, and perceived possible actions of the high-GPC participant group. Within this group, stereo 3D exposure led to more robust SSMs, experiences of sense of self-location and perceived possible actions while game playing. Stereo 3D exposure also had a medium effect ($r^2 = .35$) on the SSM, which suggests that stereo 3D

provides greater spatial cues, that is, the building blocks of SSMs. Since the high-GPC group reported playing *Call of Duty: Black Ops*, the game used as the stimuli, significantly more than the low-GPC group, it is possible that the game had higher motivational relevance, which increased the encoding, storage and retrieval sub-processes during game play that led to forming stronger SSMs. In theory, the SSM is used to organize the ERF and subsequent game-as-PERF hypothesis (Wirth et al., 2007). When the game-as-PERF hypothesis is strong, less confirmatory evidence is required to confirm it. Since stereo 3D exposure created relatively robust SSMs, provided additional confirmatory information for the perceptual hypothesis testing, and participants had greater cognitive resources, a very strong effect was observed within this group for sense of self-location ($r^2 = .67$) and perceived possible actions ($r^2 = .48$).

In some instances, low-GPC could have led to fewer allocable cognitive resources thereby decreasing SSM strength and likelihood of experiencing spatial presence. When participants were less skilled, stereo 3D exposure did not lead to significant increases in SSM strength. This was expected because individuals with low-GPC require additional cognitive resources to perform basic functions, so fewer of those cognitive resources are available for allocation to process the game's content. In fact, because the low-GPC group had less exposure to the video game used in the study, group members likely devoted fewer resources to encoding, storage, and retrieval while playing the game, which decreased their likelihood of forming strong SSMs. Although, stereo 3D exposure did not lead to the construction of more robust SSMs for low-GPC participants, it did have a significant and relatively strong effect ($r^2 = .37$) on participants' experience of sense of self-location. However, it did not lead to greater perceived possible actions.

One of the most interesting findings—for several reasons—follows: When participants were less skilled, stereo 3D exposure did not lead to the formation of stronger SSMs; however, participants did report experiencing greater sense of self-location within the fast-paced, stereo 3D condition. This finding suggests that although the less skilled group of participants did not form very robust SSMs they were capable of experiencing spatial presence. Since the SSM was not very robust for the low-GPC group, it is unlikely that a strong ERF and, later, game-as-PERF hypothesis were formed. When the game-as-PERF hypothesis is strong, less confirmatory evidence is required to accept the perceptual hypothesis; however, since there was no significant increase in SSM strength, stereo 3D exposure must have produced a relatively large degree of perceptual support to compensate for the relatively weak game-as-PERF hypothesis (Wirth et al., 2007). In addition, since the SSM was relatively weak, it would suggest that less-skilled users might not fully understand their surroundings, but that stereo 3D exposure can make them feel as though “they are there.”

It was posited that fewer cognitive resources would be available when pacing was fast, and more cognitive resources would be available when pacing was slow, and that slow pacing and stereo 3D exposure would contribute to a strong SSM in conjunction with spatial presence. Although stereo 3D exposure did not significantly increase SSM strength in the high-paced, stereo 3D condition, it significantly affected sense of self-location, which conflicted with what was expected.

Discussion

Although users who are more skilled may gain certain benefits from playing games in stereo 3D, less-skilled users benefit as well. The effects that pacing, stereo 3D exposure, and player skill have on the processes within the spatial presence model are discussed, and this

study's findings are compared to the findings of other relevant studies. Implications are discussed in greater depth. Alternative explanations for unexpected findings and the threats to external validity of the findings are presented as well.

Stereo 3D exposure facilitates the process of spatial presence in several ways. First, it may increase arousal and attention allocated toward the medium (Rajae-Joordens, 2008; Shafer et al., 2011). Second, as a visual depth cue, it works in conjunction with other visual information to build SSMs (Wirth et al., 2007). The SSM is robust when it is both rich and consistent with the spatial environment of the game. Third, in an indirect manner, the information within the SSM is used to construct ERF, and SSMs that are more robust strengthen the ERF and the subsequent game-as-PERF hypothesis. Finally, stereo 3D provides additional perceptual support for the game-as-PERF hypothesis.

Stereo 3D exposure affects the SSM and the processes within the model both directly and indirectly. When its effects were initially examined using the full sample, there was a significant increase in the SSM, sense of self-location, and perceived possible actions dependent variables. The first hypothesis suggested that when stereo 3D games are played, the spatial presence model holds for an individual regardless of his or her skill level or experience with the game; however, this may not be so. Other hypotheses examined the effects of stereo 3D exposure on the two game play competence groups as independent groups and revealed that some amount of game-related skill was crucial for successfully developing a strong SSM and important for experiencing greater sense of self-location and perceived possible actions. These findings are consistent with those shared by Wu (2010): Self-reported game skills are positively related to the strength of the spatial situation model.

Wu (2010) suggests that general video gaming skills facilitate the construction of SSMs. Wu used a basketball video game within the experimental conditions to examine the effects of self-reported gaming skills on the SSM. Wu's results suggest that general gaming skills are sufficient and that those skills are positively related to SSM strength. Some of Wu's results are contrary to some of this study's findings, which suggest that game skills alone are not a significant factor in facilitating an increase in SSM strength. Schafer et al. (2011) also analyzed participants' self-reported skills and suggested that accurate measurements of skill levels are needed. The measure of skills in this study differs from previous investigations. It offers greater fidelity because it is directly related to the game and it is an objective measure of game-related competence. Although the findings of Wu and this study differ in this regard, when stereo 3D graphics were used there was a significant increase in SSM strength; however, no significant increase was observed for participants with low-GPC.

Why does stereo 3D exposure facilitate SSM robustness for participants with more game-related skills and not for less-skilled participants? There was no significant difference between the high-GPC and low-GPC groups' prior exposure to stereo 3D content; however, there was a significant difference in prior exposure to *Call of Duty: Black Ops*, the game used as the study stimulus. One potential explanation for the development of more robust SSMs in the high-GPC group is the game's (a) greater motivational relevance that led to a greater allocation of cognitive resources to the encoding, storing, and retrieval sub-processes and (b) 3D stereoscopy provided more spatial information for assimilation than that provided by 2D images. Another potential reason resides in the possibility that greater game-playing skills may have increased participants' abilities to navigate and to explore the virtual environment. If greater skills allow users to move efficaciously within the environment and examine the surroundings, then an additional depth

cue—structure from motion—could have had a greater effect when the game is played in stereo 3D. Although an interaction between stereo 3D exposure and structure from motion is a possible explanation, it is not a likely explanation. For structure from motion to be a viable alternative, a significant effect between SSM strength and skill level would have been found, but it was not. The most likely explanation is that the traits of shooter game users equip them with greater allocable resources available from increased cognitive efficiency during game use.

Lang (2005) suggests that more cognitive resources are required for users with less skill and for those who are learning to play a game. The gap of cognitive resource availability between users of different skill levels is based upon a wide variety of factors. Some factors may relate to the cognitive requirement of learning the game, and others may be caused by differences in processing ability. For users who less skillfully operate game controls, more cognitive resources must be consumed by encoding, storage, and retrieval sub-processes for learning in-game movement and controls and the context in which perceived possible actions are performed (Lang). When virtual enemies attack a user's game character, the less-skilled user is required to shift his or her attention toward those enemies; however, that attention is not as efficient as that of the skilled gamer (Green & Bavelier, 2006b). As such, the consumption of precious cognitive resources is increased. Because each in-game encounter is a novel situation and a less-skilled game player cannot activate relevant scripts, more game-related encoding, storage, and retrieval must be performed by that user to manage game scenarios (Lang, 2005; Lindley & Sennersten, 2008). There is an additional reason that cognitive resources allocated to the game may have been greater in the high-GPC group than in the low-GPC group. The high-GPC group reported playing the game in this study as more stimulating than did the low GPC group. It is possible that the game had higher motivational relevance for the high-GPC group than for the low-GPC group

and that the effects of greater cognitive overhead and motivational relevance were additive thereby increasing the amount of encoding, storage, and retrieval that occurred within the scenario.

Greater skills provide users with various visual-cognitive efficiencies that make available adequate resources for processing media content and forming strong SSMs; less-skilled individuals have fewer allocable cognitive resources for processing game content and constructing an SSM. Although, there was not a significant difference in SSM strength between the two groups, the results suggest that when the high-GPC group played the game in stereo 3D, participants reported forming stronger SSMs and had significant increases in sense of self-location and perceived possible actions, but the low-GPC group did not. Less-skilled participants did not report forming stronger SSMs in the stereo 3D conditions and, in most cases, did not have significant experiences of sense of self-location and perceived possible actions.

When participants with greater skill played in stereo 3D, they constructed stronger SSMs. According to the spatial presence model, those participants also have an increased likelihood of forming a more robust ERF. A strong ERF can facilitate the formation of a game-as-PERF hypothesis. The game-as-PERF hypothesis is more robust and requires less confirmatory information and stereo 3D exposure provides perceptual evidence that the virtual location of the game is the primary ego reference frame. Within that scenario, stereo 3D exposure led the skilled participants to experience spatial presence, which is supported by the high levels of significance and variance accounted for in the sense of self-location and perceived possible actions variables. Those results also indicate that individuals with less skill did not form significantly stronger SSMs when they played in stereo 3D. Weaker SSMs led to less robust ERFs; consequently, the game-as-PERF hypotheses would require additional perceptual evidence to support the

perceptual hypothesis. In most instances, stereo 3D exposure did not have an effect on the less-skilled participants' sense of self-location and perceived possible actions.

The low-GPC group was mostly composed of females (83%). Schild et al. (2012) examined stereo 3D games using Vorderer et al.'s (2004) MEC-SPQ. Schild et al. discovered in some instances that males reported experiencing greater sense of self-location in conditions in which females did not. Unfortunately, no data were collected on participants' SSMs so it is unknown if there were any similarities regarding SSM strength by gender. Although gender could have had a potential role in the disparities found between the two groups in this study, it is unlikely for two reasons. First, there was no significant increase in SSM strength, and weaker SSMs decrease the propensity of users to experience sense of self-location and perceived possible actions. In this study, the low-GPC group may not have experienced sense of self-location due to weaker SSMs. Secondly, the high-paced, stereo 3D condition, in fact, did lead to significant increase in sense of self-location. Within the low-paced conditions, the stereo 3D condition was not significant: $(|X_i - X_j|) = 0.172$ and the Bonferroni critical value was 0.224. However, the calculated values are such that further study is warranted. Finally, Schild et al. did not account for player skill, which could have affected the gender differences revealed within their study.

Although stereo 3D was not a significant factor for the less-skilled group in some instances, findings suggest that the high-paced, stereo 3D condition led to a significant increase in reporting of sense of self-location by less-skilled participants. This interesting finding is counterintuitive to the initial rationale used in this study. It was expected that less-skilled participants would not have adequate cognitive resources available to construct a SSM when pacing was high. Since SSM construction is a crucial step in the process and directly affects the

game-as-PERF hypothesis, more confirmatory information would be required and stereo 3D exposure may not be capable of providing it.

Since the study finding conflicted with the study expectation, some potential explanation is offered. First, inadequate resources may have been a contributing factor of the inability of less-skilled participants to construct SSMs that are more robust. However, within the high-paced, stereo 3D condition the combination of some factors and stereo 3D likely bolstered the confirmatory evidence offered to the participants. The increased number of virtual agents may have led to greater mental stimulation during the condition and contributed to greater immersion or cognitive involvement. In that scenario, the combined effects of stereo 3D exposure, which likely increased users' attention to the media, may have engaged their senses more fully (i.e., bound) to the game and produced perceptual evidence that bolstered the game-as-PERF hypothesis.

Lee and Kim (2008) suggest that some amount of cognitive overhead might be required to experience spatial presence. Both Wu's (2010) findings and this study's findings suggest that under certain conditions greater player skill leads to the construction of stronger SSMs. Wu examined the effects of skill on the SSM, but not on the sense of self-location or perceived possible actions. As such, the findings of this study warrant an assertion that Lee and Kim's claims may be incomplete. Greater skill directly increased the strength of the SSM when stereo 3D exposure occurred, but users with less skill did not develop stronger SSMs, although they may have experienced some degree of spatial presence. This suggests the possibility that (a) greater allocable resources directly affect the initial processes of the model, namely, the construction of the SSM, and (b) allocable resources may not be as crucial as perceptual factors in the second level of the model, where spatial presence is experienced.

In terms of validity, the theoretical results of this study should be applicable when a general audience plays shooter video games. In most situations, stereo 3D exposure should bolster the SSMs of users who have greater game-playing skills. Users who are less skilled may not derive the same benefits from stereo 3D play as those with greater skills. During most circumstances, users with lesser skills may fail to construct stronger SSMs even when stereo 3D is present. Those with greater skills should experience greater sense of self-location and perceived possible actions; however, less-skilled participants may not form stronger SSMs, but stereo 3D displays may increase their propensity to experience some degree of spatial presence. Therefore, the implementation of stereo 3D may yield practical benefits to users of varying levels of skill, although the benefits of stereo 3D exposure are not equivalent for each individual.

Although the theoretical propositions supported by this research should be applicable to a relatively wide audience, there may be caveats to some of the more specific findings. This study investigated and examined the effects of the use of stereo 3D and pacing on two sample populations playing a first-person shooter, military-themed video game. A few aspects of the study's design could potentially affect the external validity of these findings. First, dissimilar games may yield different results. There should be similar findings in replications of the use of fast-paced, military-themed shooter games, such as widely popular games in the *Call of Duty* and *Battlefield* franchises. The games within these franchises have similar pacing and visual imagery. Second, this study used the multiplayer component of *Call of Duty: Black Ops* to control the number of virtual adversaries and to circumscribe the narrative. Both actions may have had a more immersive effect on the non-skilled participants than if either or both were not employed. Third, the specific findings may only be applicable to first-person shooter games.

This topic's value to entertainment is important because it illustrates that game-related skills may affect the processing of spatial cues in a video game. This research should encourage video game developers to include stereo 3D support in their video games and to prompt users to engage with the stereo 3D feature if it is available on their display. The inclusion of stereo 3D will help users with greater game-playing skills to understand more fully their surroundings, which will enhance their experience within the game. Some degree of benefit is available to less-skilled users as well. When a user is less skilled, 3D stereoscopy may not increase his or her comprehension of the virtual environment, but it may increase his or her sense of self-location or presence within that environment.

The implications of this research should also apply to areas beyond entertainment. The study of virtual reality and presence are applicable to clinical conditions such as PTSD, phobias, and addiction, and to physical therapy and physical rehabilitation (Coelho et al., 2009; Haniff et al., 2009; Riva & Mantovani, 2012; Weiss et al., 2006). First, the results of this study suggest that, in many cases, the use of stereo 3D strengthens the media-related perceptual hypothesis: the notion that an individual's senses are bound to that media instead of to the real world. Stereo 3D exposure also may present a more *perceptually pervasive* media (Ribbons & Malliet, 2010) and constitute greater perceived realism. Stereo 3D virtual reality interventions can appear more realistic. That realism may make a patient *present* within the rehabilitation environment, which is beneficial to desensitization or habituation therapies used to treat patients with PTSD or phobias. The research demonstrates that a patient does not need to be skilled with the implemented technology of stereoscopic exposure therapies that typically rely upon visual stimuli such as those that can be triggers for addiction, PTSD disturbances, and specific phobias. The findings of this study also suggest that when spatial elements are crucial to a rehabilitation exercise, stereo

3D and patients' fluency within the intervention may increase the likelihood for understanding the spatial elements of the environment thereby contributing to the success of the intervention.

Although stereo 3D technology has a wide variety of entertainment and potential clinical benefits, many consumers are awaiting the release of newer technologies such as autostereoscopic displays and virtual reality HMDs before purchasing a dedicated stereo 3D gaming display. However, it may not be necessary for consumers to wait for the release of HMDs and autostereoscopic displays because current technology can offer both inexperienced and avid game users a more realistic and enjoyable gaming experiences. The current generation of 4K 3D TVs offer users greater temporal and spatial resolution than the previous generation of stereo 3D displays. The displays of these TVs are comparable to the visual quality of the monitors used in this study and are available in larger sizes.

Limitations

This section discusses limitations of this study. Some of the limitations are borne from the shortcomings of Wirth et al.'s (2007) spatial presence model, which was used as the conceptual framework within this study. Other are defined by the study's design, methodology, and sample composition and size.

Although most of the study's measures were valid and reliable, the study was circumscribed, in part, by the disparity between the conceptual definition and operationalization of spatial presence. Wirth et al.'s (2007) model states that spatial presence is binary: either it is experienced or it is not. This definition makes operationalizing the spatial presence model difficult. The proposition that spatial presence is experienced as a binary state is problematic because the MEC-SPQ scales use ordinal data; there are no criteria to determine a point at which spatial presence begins (Nunez, 2007). Therefore, the scales only measure participants'

experiences of sense of self-location and perceived possible actions or their propensity to experience spatial presence, but not the *actual* experience of spatial presence. Second, if one or both of the spatial presence dimensions, sense of self-location and perceived possible actions are significant and have reasonable effect sizes, then investigators can only suggest that the game-as-PERF hypothesis is confirmed.

Both the high-GPC and low-GPC groups in the study had large gender disparities; therefore, it is likely that the level of playing skill variable was confounded by gender. The low-GPC group comprised mostly females, and the high-GPC group comprised mostly males. If there were potential gender effects such as those that Shafer et al. (2011) found, namely, males are more likely than females to report greater sense of self-location, then the gender disparities found in both groups may have affected outcomes. In addition, no data were collected on the domain specific interest (DSI) or motivational relevance that participants had toward first-person shooter or military-themed games. However, data were collected on the prior use of the video game played by participants for this study, which was the only variable that could be used to gauge potential interest with the mediated content. In the event that the predominantly male, high-GPC group experienced greater motivational relevance or had greater DSI, the group's participants may have been more willing to devote additional attention to the media, resulting in stronger SSMs, which led to a propensity for experiencing spatial presence.

Pacing speed implemented with the low-GPC participants may have been insufficient to overwhelm them. That represents another limitation of the study that is overcome by increasing the number of enemy bots to either 10 or 12. Boosting the number of enemy bots would raise the pacing tempo for both conditions, low and high pacing. Since one computer used in this study was slightly less powerful than the other computer, there was a limit imposed on the number of

bots to ensure that frame rates were comparable for the high and low pacing stereo 3D conditions, which made the number of bots a technical limitation as well. If this limitation were not imposed, then there would have been a greater likelihood of encountering bots more regularly and in greater numbers simultaneously in the high-pacing condition.

The monitors used in this study allowed a higher resolution and faster refresh rate than other stereo 3D displays available during data collection; however, these monitors did pose some limitations. Screen size is a factor believed to effect users' experiences of spatial presence (e.g., Lombard, Ditton, Grabe, & Reich, 1997). The monitors used in this study were relatively small compared to other stereo 3D display devices such as 3D TVs. The smaller stereo 3D display may have hindered user' abilities to construct their respective SSMS and to experience spatial presence.

Future Research

Several recommendations are made for replications and future research. During the timeframe within which this research was conducted, the technical limitations of consumer stereo 3D technology and HDMI standards led to the decision to use a smaller display, which had higher spatial and temporal resolution than available consumer 3D TV models. Since data were collected for this study, the currently available stereo 3D displays and HDMI interfaces now offer higher temporal and spatial resolutions. Lombard et al. (1997) suggests that larger screens can facilitate the sensation of presence; therefore, future research should utilize stereo 3D technology with them. Virtual reality HMDs have stereo 3D capabilities and act as a display device and a partial interface device, allowing the user to "look" around in a virtual environment. Virtual reality HMDs have been available for years, but there were no plans to mass produce affordable consumer versions until recently. Future research should focus on newer high-

resolution stereo 3D display devices, such as 4K 3D TVs, multi-monitor stereo 3D displays, and consumer HMDs, to better understand how stereo 3D display type, pacing, and player skill levels affect the processes within the spatial presence model.

Researchers should continue to examine effective manipulation and control for pacing. This can be achieved in various ways. The methodology of this study can be supplemented with an increase in the number of enemy bots. Data collected on the actual number of virtual adversaries with which the user engages can be controlled statistically. For example, researchers could record in-game video from the experimental conditions, code, and analyze them later. Some games allow the user greater control over the quantity, behavior, and characteristics of virtual enemies within the video game. Expansions, such as *Arma 3's Zeus DLC*, allow other players to place the virtual enemies directly into an environment with other people in real time. This type of software could allow investigators to control pacing directly by placing enemies within the immediate spatial area or within the direct view of participants. Finally, researchers could use widely available game software development kits to change in-game assets and to add or remove virtual agents from the game environment. As a user moves through a specified spatial area, he or she experiences the amount of pacing regulated by the researcher.

Time and space represent another variable set that should be considered in future research. Within this study, three minutes were allotted for exposure to each experimental condition. That design decision was based on Lee and Kim's (2008) finding that their condition of 90 seconds may not have been sufficiently long enough for participants' mental representation of the environment to become stable. If more time is allotted, then, possibly, less-skilled participants can assimilate more information into their respective SSMs. The time allotted for participant exposure to the virtual environment is an area to be considered and carefully

examined. Wirth et al. (2007) suggests that, at any time, the SSM is a complete structure; yet, it varies in its robustness. It is possible that the size and spatial characteristics of the virtual environment have a role in the processing of the virtual space; the space should be neither too large nor too small for the time allotted in an experimental condition.

Future research should consider the study design and methodology used. Within-subjects design is efficient for collecting data from fewer scale items; however, a between-subjects design would allow additional data collection for other concepts such as cognitive involvement, immersion, and flow. Other variables could be measured to assess the discomfort associated with stereo 3D technology or motion sickness associated with HMDs. These variables could help increase our understanding of the processes and barriers involved with experiencing spatial presence with these emerging technologies. Other recruitment strategies should be employed to create user groups that are gender balanced.

Future investigations should examine the effect of third-person point of view play on the processes within the model. Although third-person point of view may not alter a skilled user's perception of the environment, it could affect users with lesser skills. Since users with less skill are less able to manipulate their view of the game environment, a third-person perspective may facilitate SSM construction because it provides a wider angle view and is more conducive to understanding an avatar's position within the spatial environment.

Video game graphics become increasingly realistic every year, and newer graphics processors and higher resolution displays become available; therefore, the effects of increasingly photorealistic graphics should be investigated. Since no additional spatial cues are present when higher resolutions are used, it is expected that the SSM will not be positively affected by greater photorealism, but that the game-as-PERF hypothesis is strengthened. However, the

possibility exists that higher resolution graphics could cause more controlled and uncontrolled attention to be directed toward the media thereby increasing the overall amount of attention directed toward the game media and consequently strengthen the SSM.

Psychophysiological data can provide data to corroborate findings. For example, researchers could use methods such as electroencephalography (EEG) to evaluate the prefrontal asymmetry associated with mental load during game use. This would bolster the argument that greater skills result in less cognitive load required during game play. Skin conductance level (SCL) could provide researchers with information concerning arousal; user heart rate may allow measurement of the sub-process of encoding, during exposure to stereoscopic mediated content.

Future directions should address the methods by which video game skills are measured. This study has differentiated itself from previous research by using an objective, game-related measure of skill to examine the variables within the spatial presence model. The metric developed for this study to measure game play competence may not translate easily to other games. For example, in realistic tactical shooter games (e.g., *Arma 3*), the complexity of the game does not allow users to move within the scenarios and dispatch enemy as quickly as in *Call of Duty: Modern Warfare 2*. Since the measure of skill used in this study applies only to the *Call of Duty* franchise and similar types of games, future research must determine which aspects of player skill are transferable to other games in the genre. The following question should be addressed: Should data be collected on perceived video game skills or on specific game-related abilities?

This dissertation examined video game use from the context of a virtual environment in a multiplayer setting. This was essential for this study since it isolated other variables such as narratives, which may have increased a participant's immersion level. In the future,

investigations should examine games with differing levels of narrative to determine the effects, if any, when a storyline is present within a scenario. The effects of stereo 3D exposure in first-person and third-person play should be compared and examined to determine SSM formation with its concomitant sense of self-location and perceived possible actions dimensions. Finally, additional game genres (e.g., adventure, racing, role-playing) should be investigated to examine the effects of stereo 3D exposure, pacing, and player skill levels.

Final Words

Based on the conclusions drawn from this study, it is advised that video game developers continue to support stereo 3D as a product feature. When video game engines offer built-in support, little effort is required to produce stereo 3D games, and some games may generate modest revenue streams for the cost of little or no effort. Stereo 3D graphics help users orient themselves to the spatial environment, which can lead to greater immersion and enjoyment (Ellis et al., 2011; Rajae-Joordens, 2008; Shafer et al., 2011; Takatalo et al., 2011). Regarding spatial presence, skilled players will gain the most benefit from stereo 3D because they will better understand their surroundings and experience greater sense of self-location and perceived possible actions. Although stereo 3D technology may not be as useful to less-skilled users for processing their spatial environment, they may experience some degree of spatial presence. Whether stereo 3D is used in current generation displays or is implemented in newer technology, such as autostereoscopic displays and HMDs, it is a valid and natural progression of gaming. In conclusion, although stereo 3D exposure may not provide less-skilled users with all the benefits that users with greater skills gain, stereo 3D exposure may be the factor that generates their feelings of greater engagement with the game.

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Appendix A: Pre-exposure Questionnaire

Participant ID _____ code _____

Please rate your agreement to the following.	<i>Strongly Disagree</i> (1)	<i>Disagree</i> (2)	<i>Neutral</i> (3)	<i>Agree</i> (4)	<i>Strongly Agree</i> (5)
1. When someone shows me a blueprint, I am able to imagine the space easily.					
2. It's easy for me to negotiate a space in my mind without actually being there.					
3. When I read a text, I can usually easily imagine the arrangement of the objects described					
4. When someone describes a space to me, it's usually very easy for me to imagine it clearly.					

Please rate your previous use of the following:	<i>Never</i> (1)	<i>(2)</i>	<i>(3)</i>	<i>(4)</i>	<i>Frequently</i> (5)
5. To what degree have you played Call of Duty: Black Ops (single player or multiplayer) before?					

6. Approximately how many 3D movies have you seen? _____

7. Have you ever played any video games using a 3D monitor or 3DTV? :
 ___ Yes ___ No

8. Gender : ___ Male ___ Female

9. Age: _____

10. Ethnicity:
 ___ White ___ African American ___ Hispanic ___ Asian or Pacific Islander
 ___ Native American ___ Other

11. Classification
 ___ Freshman ___ Sophomore ___ Junior ___ Senior ___ Graduate Student
 ___ Other

12. How much time do you spend playing computer or video games during a typical week?

___ None ___ 1 - 3 hours ___ 4 - 10 hours ___ More than 10

Appendix B: Post-exposure Questionnaire

Please rate your agreement to the following:	<i>Strongly</i>				<i>Strongly</i>
	<i>Disagree</i>	<i>Disagree</i>	<i>Neutral</i>	<i>Agree</i>	<i>Agree</i>
	(1)	(2)	(3)	(4)	(5)
1. It was as though my true location had shifted into the environment in the game.					
2. I was able to imagine the arrangement of the spaces presented in the game very well.					
3. The objects in the game gave me the feeling that I could do things with them.					
4. I thought most about the things having to do with the game					
5. I had the impression that I could be active in the environment of the game.					
6. It seemed as though I actually took part in the action of the game.					
7. I felt like I was actually there in the environment of the game.					
8. I was able to make a good estimate of the size of the space presented in the game.					
9. I thoroughly considered what the things in the game had to do with one another					
10. I felt like I could move around among the objects in the game.					
11. Even now, I still have a concrete mental image of the spatial environment of the game.					
12. I had a precise idea of the spatial surroundings presented in the game.					
13. I felt as though I was physically present in the environment of the game.					
14. I thought about whether the game presentation could be of use to me					
15. It seemed to me that I could do whatever I wanted in the environment of the game.					
16. The presentation activated my thinking					

Appendix C: Bonferroni's Multiple Comparisons Analyses

Hypotheses	Comparison	Var.	DF	Prob.	T-value	MSE	Ni	Nj	Xi	Xj	Xi-Xj	B	Sig.
H1	Low-pacing, 2D vs Low-pacing, 3D	SSM	56	0.025	2.003	0.419	57	57	3.500	3.890	0.390	0.242	*
H1	High-pacing, 2D vs High-pacing, 3D	SSM	56	0.025	2.003	0.419	57	57	3.544	3.842	0.298	0.242	*
H2a	Low-pacing, 2D vs Low-pacing, 3D	SL	56	0.025	2.003	0.671	57	57	3.066	3.693	0.627	0.307	*
H2a	High-pacing, 2D vs High-pacing, 3D	SL	56	0.025	2.003	0.671	57	57	3.099	3.838	0.739	0.307	*
H2b	Low-pacing, 2D vs Low-pacing, 3D	PA	56	0.025	2.003	0.363	57	57	3.439	3.715	0.276	0.226	*
H2b	High-pacing, 2D vs High-pacing, 3D	PA	56	0.025	2.003	0.363	57	57	3.349	3.753	0.404	0.226	*
H4	Low-pacing, 2D vs Low-pacing, 3D	SSM	27	0.025	2.052	0.486	28	28	3.491	4.080	0.589	0.382	*
H4	High-pacing, 2D vs High-pacing, 3D	SSM	27	0.025	2.052	0.486	28	28	3.607	4.027	0.420	0.382	*
H5	Low-pacing, 2D vs Low-pacing, 3D	SL	27	0.025	2.052	0.644	28	28	2.679	3.777	1.098	0.440	*
H5	High-pacing, 2D vs High-pacing, 3D	SL	27	0.025	2.052	0.644	28	28	2.863	4.000	1.137	0.440	*
H6	Low-pacing, 2D vs Low-pacing, 3D	PA	27	0.025	2.052	0.416	28	28	3.259	3.768	0.509	0.353	*
H6	High-pacing, 2D vs High-pacing, 3D	PA	27	0.025	2.052	0.416	28	28	3.244	3.946	0.702	0.353	*

Other Analyses:

Low-Pacing Group Self-Location Comparison

Low-pacing, 2D vs Low-pacing, 3D	SL	28	0.025	2.048	0.205	29	29	3.440	3.612	0.172	0.243	n.s.
High-pacing, 2D vs High-pacing, 3D	SL	28	0.025	2.048	0.205	29	29	3.328	3.681	0.353	0.243	*

Stereo 3D x Pacing x GPC (Gender as Covariate) on SSM

Low-pacing, 2D vs Low-pacing, 3D	SSM	54	0.025	2.007	3.262	57	57	3.491	4.080	0.589	0.679	n.s.
High-pacing, 2D vs High-pacing, 3D	SSM	54	0.025	2.007	3.262	57	57	3.607	4.027	0.420	0.679	n.s.

Stereo 3D x Pacing x GPC (Gender as Covariate) on SelfLocation

Low-pacing, 2D vs Low-pacing, 3D	SL	54	0.025	2.007	5.707	57	57	2.679	3.777	1.098	0.898	*
High-pacing, 2D vs High-pacing, 3D	SL	54	0.025	2.007	5.707	57	57	2.263	4.000	1.737	0.898	*

SSM - Spatial Situation Model

SL - Self-Location

PA - Possible Actions

Appendix D: IRB Approval

Office for Research
Institutional Review Board for the
Protection of Human Subjects

November 8, 2012



Damien Larkin
College of Communication & Information Sciences
Box 870172

Re: IRB Application # 12-022
Application Title: Spatial Presence in a 3D Shooter Game: The
Effects of Stereo 3D and Pacing

Dear Mr. Larkin:

The University of Alabama IRB has received the revisions requested by the full board on 10/19/12. The board has reviewed the revisions and your protocol is now approved for a one-year period. Please be advised that your protocol will expire one year from the date of approval, 10/19/12.

If your research will continue beyond this date, complete the IRB Renewal Application by the 15th of the month prior to project expiration. If you need to modify the study, please submit the Modification of An Approved Protocol Form. Changes in this study cannot be initiated without IRB approval, except when necessary to eliminate apparent immediate hazards to participants. When the study closes, please complete the Request for Study Closure Form.

Should you need to submit any further correspondence regarding this proposal, please include the assigned IRB application number. Please use reproductions of the IRB approved stamped information sheets to obtain consent from your participants.

Good luck with your research.

Sincerely,



Stuart Usdan, PhD.
Chair, Non-Medical Institutional Review Board
The University of Alabama

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